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The Responsibility for the Quebec Bridge Failure.

The full report, with its important appendices, of the Royal Commission appointed to investigate the Quebec bridge failure, published in The Engineering Record of a week ago, afford opportunity for determining a number of questions hitherto open regarding the responsibility for the design and construction, as well as the failure, of the great structure in question. It has many times been stated that this failure reflects most damagingly upon the engineering profession in America, in fact many engineers have felt that the professional capacity of American engineers in general is seriously compromised by the failure to construct and erect the Quebec bridge successfully. At first sight, there is apparently substantial ground for this imputation, but a careful reading of the testimony brought out during the examinations carried on by the Royal Commission will indicate that this appalling disaster had its origin in something fundamentally different from any general lack of ability of American engineers to design, construct and erect far greater structures even than any hitherto contemplated.

In passing judgment upon such a case as this, it is imperative to deal squarely with the facts as they are brought out in the evidence, irrespective of any other consideration whatever. Personal sympathies or professional sentiments have no place in the analysis. It should be the purpose of such an investigation to treat every interest involved with absolute fairness and so to arrive at a conclusion absolutely just and unprejudiced, even though it appears to be unfeeling. While it is not the purpose of these comments to anticipate or to affect in any way actions that hereafter may be taken in consequence of what may be determined to be the legal obligations of any of the parties in interest, it is essential that some elements of the broad question of responsibility should be most carefully considered for the future guidance of both engineers and owners.

As has been indicated before in these columns, the complete general and shop drawings of this structure originated in and were made by the engineering organization of the Phœnix Bridge Co., that company, one of the oldest in the country, having had for many years a large and experienced engineering staff. As these plans were developed they were submitted for the examination and approval or disapproval of the consulting engineer who had been made absolutely supreme in authority by an Order-in-Council issued by the Canadian government. It is brought out in the evidence that this transmission and submission of plans was no mere formality nor in any degree perfunctory. This evidence shows that matters like the anchor-arm upper-chord plan, change of lateral bracing in floor system, expansion detail between suspended span and cantilever arm, and many other matters, greater or less, were subjects of extended consideration and discussion between the contractor's engineer and the consulting engineer before receiving the latter's approval. In fact, it is conclusively brought out that the complete stresses and plans, both general and detail, were thoroughly and even drastically examined before being approved by the consulting engineer under specifications largely prepared by and wholly approved and, in substance, officially promulgated, by him. It is seldom that the responsible engineer for any work great or small has more authoritatively or more effectively impressed his engineering judgment upon the work in his charge than in this case.

It appears that the president and other officials of the Phœnix Bridge Co. observed the extreme lightness and weakness of the angle lattice bars on the lower-chord segments of the anchor arm, where the failure began, while those members were being manufactured in the shops. It was found to be impossible to handle those chord pieces without bending the light lattice bars. This so disturbed the inspectors and engineering staff of the Phœnix Bridge Co. that the Consulting Engineer was at once notified and requested to examine and consider the sufficiency of the lattice bars for the duties which they were to perform. He approved them, however, and accepted them as sufficient for their purpose without even going to the shop to examine them, as the evidence appears to indicate. This action would seem to relieve the Phœnix Bridge Co. of responsibility in the premises. It is most unfortunate that it did not peremptorily decline to ship these members without strengthening the latticing, although such an action, technically speaking, would have been without justification.

Perhaps the most painful part of the evidence is that in which the Consulting Engineer makes the plea of impaired health for not exacting from both the contractor and the Quebec Bridge Co. certain requirements of design and plans in the one case, and the necessary organization for the proper performance of the work in the other. Unfortunately such pleas are admissions of official shortcoming: however much a man may feel the disabilities of ill health, they give him no relief from official responsibility. There is one only clear way by which he can divest himself of the responsibilities of official position and that is by a formal withdrawal from it. It is idle to say that the contractor was reluctant to make the changes shown to be wise or necessary by the consulting engineer's own revision of plans, or that he could secure them only with difficulty. If he failed to secure them, either with or without difficulty, he failed to discharge his duty and freed the contractor from responsibility. As a matter of fact, the Consulting Engineer stated in the evidence that the contractor did make revision of the plans directed by him; nor does there appear any instance where that result was not attained except in case of the revision of his own suggestions by the Consulting Engineer. It should be stated, in all fairness, that the latter's evidence as to these points is at variance with that of the officials of the Phœnix Bridge Co.

The Consulting Engineer makes a further point in his evidence that the fee which he received was quite insufficient to enable him to maintain a proper office force for the discharge of the duties imposed upon him in his official capacity. He is entirely correct as to the fee stated in the evidence being too small. It was absurdly meagre and the Quebec Bridge Co. invited disaster when it sought suitable professional service at such mean compensation. The Consulting Engineer, however, had the means to meet the situation by demanding a proper compensation or withdrawing from the work. When he accepted the fee he accepted all the responsibilities of the position. No engineer has any right whatever to consider his responsibilities lessened because his fee is not as large as it should be. If he thinks he should fairly have more compensation, it is his right to require it, but failing that, he has no right to assume that his responsibilities are correspondingly lessened, or to act as if he made such an assumption. The failure of the Quebec bidge reflects in no way whatever upon the American engineering profession, it simply shows that the exactions of responsibility unfortunately make no compromise with the disabilities of age and ill health, even when combined with a meagre compensation.

The Rating of Gas.

The gas companies of this country have suffered long from the survival of the ancient laws made before the introduction of mantle burners and gas engines, and the time is ripe for a change. The statute books of practically all the States which have any regulations regarding gas contain condle-power specifications based on a flat-flame burner and the old English sperm candle. This standard has long been discredited in the country of its birth, and has never at any time been satisfactory in precision. Candles give all sorts of irregular results, even in the most careful hands, and in England have been discarded in favor of the 10-c.-p. pentane standard which practically represents a conventional average of candles based on the experiments of many years. It is widely used in this country as the practical standard, but the candle itself, with all its imperfections, still has legal force. To-day, however, so large a proportion of gas is used in mantle burners and for power purposes that from a practical standpoint the candle has lost most of the significance that might still attach to it. The ordinary consumer with an eye to economy uses gas in mantle burners, and for such use its putative candle-power has little significance. The real value of the gas lies in its thermal value and the old light specification is really a discrimination against modern methods in favor of those which are a decade or two behind the times.

The man, too, who uses gas for power purposes does not care how much it is enriched for illuminating purposes. What he wants is power at the lowest practicable price, and this can be obtained to the best advantage from gas in which illuminating power is subordinated to heating value. Of course, there is the question of distribution to be considered, which would check, for instance, the general supply of such gas as is obtained from the ordinary producer. Common producer gas running from 100 to 150 B.t.u. is rather too lean for anything but use on the spot. The problem of gas for heating and power is the problem of minimum cost per thermal unit, including the distribution. On the successful production of gas designed to meet this requirement the candle-power specification is a severe handicap. In the interest of modern industry, is it not high time to rate gas on its thermal value and to drop specifications for the benefit of those who misuse it? Looking at the matter broadly, from the standpoint of the public, the really important uses of gas to-day are for heating and for power, rather than for lighting. The electric light has pushed gas already out of a large part of the lighting field, and the recent improvements in both arc and incandescent lights make it highly probable that every year will see the purely lighting field for gas more and more restricted. Its survival will be mainly in the use of powerful mantle burners which, for certain kinds of work, are unquestionably cheap and efficient. On the whole, the public is gaining from the change, but the possession of cheap gas for heat and power remains of great importance since it automatically prevents electric companies from unduly screwing up their lighting prices.

The electric plant driven by gas engines is a cheap source of light and power, but is handicapped over most of the country by the fact that the only gas available is illuminating gas, which, even with heavy discounts, is far more costly than fuel gas proper. More than this, fuel gas for ordinary heating purposes is an article that is badly needed for future consumption. Fuel gas can be put within striking distance of anthracite for heating, considering the price of the latter and the cost of running fires and of ash disposal. In the less economical branches of heating, such as cooking, it could and would run coal out of the business. Householders well know that a gas range, even with fairly cheap illuminating gas, saves money over coal, but is unsatisfactorily costly when it comes to hot-water supply. A regular fuel gas would solve the problem of domestic heating very successfully, as natural gas has where it is available. If gas were rated simply on its heating value and no especial attempt were made to use it for light save in mantle burners, the way would be open for a cheap gas supply that would extend the consumption of gas enormously and bring good returns from the increase in absolutely new business. As it is now, coal users pay enormous tribute for transportation and use their fuel, as a rule, most uneconomically. With plentiful and cheap gas supply, the smoke nuisance would be in great measure abated, and everybody save the old fogies would be pleased. The ideal city would be one in which no fuel of any account was burned, heat being supplied from fuel gas, light from electric plants far without the boundaries, and power from gas or electricity, as might prove in each instance the more economical. The present waste of fuel is an economic outrage for which the world will pay dear a century hence, if not earlier.

The Application of the Sliding Scale to Public Service Corporations.

The advantages which may accrue from a condition of mutual confidence between the community, the public service corporation, and its employees, are well evidenced in the results of the limited applications of the sliding scale that have been made up to the present time. When applied in its complete form under government control, it has shown coincident decrease in cost, increase in dividends, decrease in selling price, and increase in wages. In a word, the scheme is fundamentally one of profit sharing. Reduction in cost is secured through the co-operation of the employee. From the highest to the lowest, the incentive of receiving a definite share in the profits must be conducive to increased efficiency and to a feeling of personal interest in the success of the company. Of course, the extension of such privileges of participation in profits must be gradual. The result of the first step must be assured before a second is taken. Naturally the high officials should be the first to share, for their interest in and contact with the business is most direct. The common laborer is very properly the last to share. One of the conditions of participation applicable to all should always be consecutive duration of service. From this a twofold advantage results: higher individual efficiency due to better acquaintance with the work, and higher corporate efficiency as a result of uniform systematic continuance of established methods.

The public, on its part, is brought into closer touch and sympathy with the corporation. Publicity of accounts and reduction of prices begets confidence. There is a direct public interest in the efforts of the corporation to extend its operations, to improve its service, to encourage the consumer to fuller utilization of facilities, though his total payments to the company be thereby increased. Complaints decrease or become far less vituperative, suggestions supplant criticisms. A trouble department, diplomatically managed, may be one of the greatest indirect sources of increasing business. The consumer cannot fail to be influenced by an honest motive to give him the best service, to help him personally to get his full money's worth.

The corporation itself finds under the operation of the sliding scale an incentive to honest business methods, to a consideration of both employee and consumer, to a bending of all energies toward improvement. Such incentives in whole or in part are all too often lacking under other conditions of management. The establishment of uniform systems of accounting is doing much to present the business of municipalities and public service corporations in a light for better understanding and comparison.

It is a fundamental principle of individual service that the highest efficiency is secured where the personal interest is greatest. To this end the interests of employer and employee must be mutual; confidence must be maintained between them. This seems to be directly secured through the development of the sliding scale system, so far as it has been tried.

A consideration of the consumer by the corporation opens the channel through which increased business may flow, creates confidence that improvements may be for the sake of the consumer as well as for the interests of the producer, that both may at the same time be legitimate sharers in the profits. It is far better policy to make a friend of the public than to turn it into an enemy.

Energy is devoted to improvement under these conditions in a manner and to a degree not possible otherwise. With limits specifically set by statute or regulations, there is little or no fear of further legislative interference; in fact, independence of action is usually assured for a specific and somewhat extended period. As a rule, these conditions cannot fail to result in conservation of energy and funds, through the removal of uncertainty regarding government control. Attention can be given to the legitimate business of producing and selling, and not diverted to a defense of methods, the combating of proposed inimical legislation, and the maintenance of a watch on guard.

The sliding scale in whole or in part has already been applied in many private industries. But although peculiarly fitted for some public service corporations, its adoption in connection with them has been limited.. The satisfactory experience of the city of London with its application to the gas industry has given special encouragement in support of its trial in this country, and the results will be watched with interest.

Notes and Comments.

A Transcontinental Railway System governed by one dominant influence has at last resulted from the purchase of the control of the Central of Georgia Ry. by Mr. E. H. Harriman. This road has an Atlantic terminus at Savannah and a connection with the Illinois Central R.R. at Birmingham. In this way it will shortly be possible for a shipment from the Pacific Coast to be run alongside a seagoing vessel in the Southern port without leaving the car in which it starts. This is on the assumption, of course, that the new Eastern portions of this system will be operated in the same general manner as the lines west of Chicago, on which the methods of handling shipments have been greatly improved of late years. The effect of this connection on the foreign commerce of Savannah will be well worth watching. The Harriman lines already have terminals at Galveston, which ranks second among American exporting ports, and at New Orleans, which is expected to forge ahead rapidly after the completion of the Panama Canal, particularly if the navigability of the Mississippi and its tributaries is improved. Under the circumstances it is somewhat difficult to see what noteworthy gain arises in having an Atlantic outlet so far south as Savannah unless it gives the Harriman interests a strong position in making through rail and steamship rates and in the fight for differentials. The new owners of the Central of Georgia Ry. have never been noted for taking the public into their confidence before their plan of action was perfected and its success assured, and consequently it will be necessary to wait for future developments to show what is to be done with the road. It is perfectly safe to assume, however, that in these days of manifold attacks on railway companies from persons of high and low degree, that nobody is spending $3,000,000 for the control of a Southern road that is not paying dividends without a pretty fair certainty of securing a fair return of one sort or another for such a large investment.

A Unique Construction Achievement recently accomplished in Chesapeake Bay was described in this journal last week. The attempt to sink a caisson 48 ft. square to a depth of about 80 ft. below water level in the open seaway of that bay is a pretty stiff undertaking in itself. But to tip up such a caisson after it has been allowed to fall over on its side in water so deep that only a few feet project above the surface, is a task to shun. Mr. Wood had to do it to save the credit of the surety company which was on the bond of the original contractors, and the story of the manner in which the work was done, as told in much detail last week by Mr. Kiefer, is one of the most interesting The Engineering Record has printed in a long time. The work was done by building a very strong lever arm out from the top of the overturned caisson and weighting it with pig lead at its end, so that a comparatively small strain with a couple of hoisting engines turned it up on end where it belonged in about a minute. The novelty of the process is likely to overshadow the vital feature of the work, the complete preparation to meet all probable contingencies in an open seaway. The surety company, after one unsuccessful attempt to right the caisson through the agency of a subcontractor, took up the task in a thorough manner. It built a substantial wharf around three sides of the site, provided all necessary equipment, and left nothing to chance or luck. Its success in building the pier after the failure of two previous attempts shows the value of good plans properly executed. Anybody who undertakes such work in any other way is gambling with chance, and the fickleness of chance is proverbial.

FORESTRY WORK is so old and its beneficent results are so thoroughly proved by wide experience in Europe and Asia that it is surprising to notice the general American belief that it is an untried, unpractical novelty. While it is new in most parts of the United States, this is merely because the condition of our timber supplies did not make it imperatively necessary until recently. Figures collected by the U. S. Forest Service show that when Germany began its forestry work in 1830, its forests were in as bad shape as our own today, which have been recklessly cut over. Since then the average yield of wood per acre has been raised from 20 to 65 cu. ft., the proportion of saw timber from the average cut has been trebled, and the money value of the returns from an average acre of forest has been increased sevenfold. Forestry on State lands in France, costing per acre for their management over a hundred times our appropriations for the purpose, yields an annual net revenue of nearly $5,000,000. This monetary return is only a part of what forestry has accomplished. Years ago the floods that threatened to ruin great tracts of fertile lands were so serious that the government began to set out trees on the steep slopes of the headwaters of the destructive streams, in order to regulate the runoff. This purpose has been accomplished, while the forests themselves are a source of revenue. Forestry in Switzerland is so successful in protecting the fertile valleys from floods that the federal methods have won a high reputation and the schools where they are taught attract students from many countries. Hence the United States is not led away by any new fancy of questionable value, but, on the other hand, it is trying through its Forest Service to apply to American conditions the lessons that other countries have learned at great expense, in order that our supplies of timber may be used in a rational rather than a wasteful way, and provision may be made for future needs.

FUEL OIL is to be substituted for coal wherever practicable at stationary boiler plants along the Panama Canal. The Union Oil Company of California has an 8-in. pipe line across the Isthmus practically parallel with the Panama Railroad, and a contract has been made between it and the Canal Commission under which the company is to furnish crude oil at any convenient point along this line at the rate of 90 cents a barrel. It is proposed to take 4-in. branches from the main and run them to large tanks placed some distance above the boilers of the plants in which the oil will be used. These tanks will hold approximately one month's supply. The oil will be fed by gravity to the burners of the steam-jet type attached to the furnaces, and an attempt will be made to heat the air under the boilers before it comes into contact with the oil. Oil has been used at the La Boca electric light plant for some time, where $2.70 worth of oil does the work of $6.35 worth of coal.

THE DELAYS TO SHOP OPERATION that are often accredited to the individual electric drive for machine tools do not appear to be a serious factor in a completely equipped and well organized shop plant. At the large McKees Rocks locomotive and car repair shops of the Pittsburg & Lake Erie R.R., near Pittsburg, which are equipped throughout for individual motor driving of tools, the average length of the periods of delay to tools due to motor troubles during the year of 1907 was only about 17 minutes. While there are a total of 84 motors in use for machine driving at these shops, the total number of the above delays for the year was 93, an average of 1.1 delays per motor per year, and the longest delay was but 1¼ hours. The total time of all motor delays to tools during working hours was 26½ hours, which resulted in a loss by enforced idleness of the machinists time (valued at an average of 27½ cents per hour) of only $7.30. In order to minimize such delays, standard sizes of motors only were installed, and spare armatures and controller parts are kept on hand for each size, permitting emergency repairs to be quickly made.

THE INSTITUTION OF MECHANICAL ENGINEERS, according to the report of its Council submitted last month at the 61st annual general meeting, is now in a most prosperous condition. It has a membership of 5,238, including the class of graduates, which is a net gain of 259 over the membership of a year ago. The total revenue for the past year was about $70,000 and the expenses about $55,000. Its investments and other assets amount to $400,000, and it has outstanding $125,000 of debentures and other liabilities. To the American engineer, the most interesting feature of this report is the statement of the progress of various researches that are being made with the help or under the direction of the society. The work of two of these research committees is particularly well known, those having to do with alloys and with the operation of gas engines, but there are others which may be expected to furnish valuable data to the engineering profession when their labors are completed. The encouragement given by the institute to research work is like that extended by the great Society of German Engineers for the same class of investigation, and indicates a somewhat different policy from that generally adopted by American engineering societies.

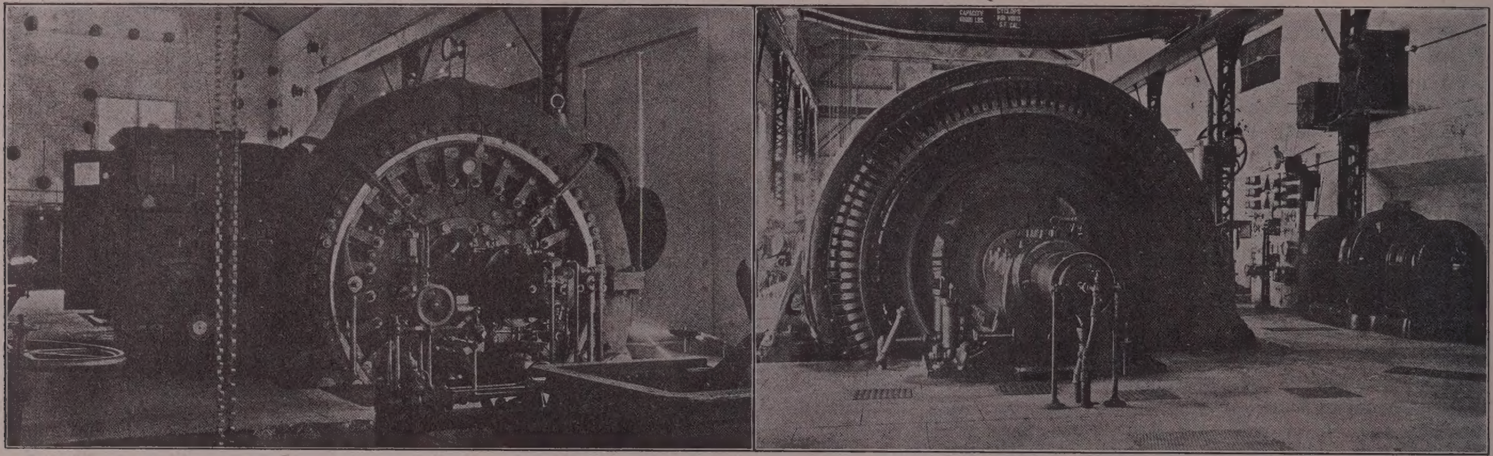
THE ST. LAWRENCE CHANNEL IMPROVEMENTS begun in 1899 are now approaching completion and but 11 miles of dredging remain to complete the 30-ft. channel from Montreal to the ocean. Until 1904 the work was under the Department of Public Works and since then has been directed by the Minister of Marine and Fisheries. The improvement covers the entire distance of 340 miles from Montreal to Father Point, but has been concentrated mainly on the 220 miles from Montreal to the Traverse, in which distance 75 miles of channel have already been excavated, leaving 11 miles still to be improved, as before stated. This channel has a minimum depth of 30 ft. and a minimum width on the straight reaches of 450 ft., the width being considerably increased on curves. Permanent range lights will soon mark the channel from one end to the other and there is a departmental telephone line running along the river from Montreal to Crane Island, below Quebec. About sixty gas buoys have been set out between Montreal and Quebec, and every provision is being made to render the route easy to traverse, and thus bring about a reduction of the heavy insurance rates which have heretofore proved adverse to St. Lawrence shipping. That some such improvement in the old financial conditions is certain to occur is shown by the announcement that the Compagnie Général Transatlantique will transfer two of its vessels from New York to Montreal. The development of the shipping by this route will be watched with interest as it will indicate quite clearly the effect of channel improvements on existing commercial avenues.

THE WEST SIDE RAILROAD TRACKS used by the New York Central & Hudson River R. R. to deliver freight cars in New York as far south as Beach and Hudson streets continue to be a most perplexing problem to those who believe that such occupation of busy streets is an anachronism. The operation of cars on 11th avenue, between 59th and 30th streets, causes a great deal of inconvenience, to say nothing of the occasional injury or killing of children. Complaint has been made that the Public Service Commission has not been giving proper attention to the abolition of these conditions, which are rapidly becoming so burdensome that popular indignation may bring about some hasty action that will be as unfortunate for the city as for the railroad company. As the matter now stands, under the so-called Saxe law, the Public Service Commission has done all that it legally can by preparing plans and maps of the railroad property on the city streets and submitting them to the Corporation Counsel to commence condemnation proceedings. But it is generally believed by those who have looked into the matter carefully, that such proceedings would be a grave mistake on the part of the city. The railroad company is already willing to put its tracks in a subway as far south as 30th street provided it is given a franchise for extra freight tracks from Spuyten Duyvil Creek to 30th street. The cost of this work will be enormous, and for the city to accept the offer means the saving of a large sum. On the other hand the franchises for additional freight tracks are very valuable. Be that as it may, however, this project does not provide for any extension of the tracks south of 30th street, and although the number of cars used on this southerly portion of the tracks is relatively small, the problem of providing for them is troublesome financially as well as from an engineering point of view. There seems to be little difference of opinion among those who have investigated the subject most carefully that some means of freight car communication along the west front of the city is very desirable. While the steamship lines will furnish comparatively little business to such freight lines, the produce and refrigerating business is so thoroughly established in this district and demands such complete transportation facilities that the necessity of providing a freight line is generally acknowledged. Although the Public Service Commission does not express any definite opinion on the subject, it has apparently reached the same conclusion as most of those who have investigated the matter, that an elevated freight line, like that in Liverpool, running along the so-called "farm" between West street and the docks along the North River is the best and cheapest method of furnishing the desired facilities. Such an elevated line with its spurs into warehouses and docks will cost far less than a subway and will be located on city property among surroundings which will not be prejudicially affected by an elevated structure.

A HIGH-HEAD REACTION TURBINE INSTALLATION.

The California Gas & Electric Corporation, of San Francisco, has recently placed in service in a hydro-electric generating station at Centerville, Cal., a 9,700-hp. hydraulic reaction turbine, designed to operate under an effective head of 550 ft. The station in which this unit is installed is a part of the extensive generating system of that corporation from which power is distributed to practically all of the cities within a radius of upwards of 100 miles of San Francisco. The development is about 200 miles northeast of that city on Butte Creek, one of the numerous streams on the western slope of the Sierra Nevada Mountains. The 14,000-kw. de Sabla hydro-electric station of the system of which the one at Centerville is also a part is approximately 8 miles upstream from the latter and has been in service for several years.

The flow of Butte Creek at the de Sabla station, although comparatively large, has been increased considerably by the construction, on the watershed above that point, of several reservoirs for impounding a part of the flood waters. The water discharged from this station is diverted into an open canal, about 8 miles long, that leads to the Centerville station. This canal, which was built originally for hydraulic mining purposes, has been enlarged and entirely reconstructed to a carrying capacity of 175 cu. ft. per second. It is generally in a bench cut following the contours of the stream at a much flatter grade than the latter. As the creek drops away rapidly, a difference in elevation of 591 ft. is obtained between the end of the canal and the tail race at the Centerville station.



Reaction Water Turbine and Alternator in Centerville Hydro-Electric Station.

An overflow concrete dam was erected across the creek at the upper end of the canal to divert water into an approach to the latter. The flow into this approach is controlled by two large sluice gates. The approach is 150 ft. long, and is built with converging sides, its width being somewhat greater than that of the canal at the upper end. The bottom of the approach is also built on a sufficient grade to bring it to a level 4 ft. below the bottom of the canal at the end of the approach, thus forming a settling basin in which the coarser materials carried by the stream during certain flood conditions are deposited. These materials are readily sluiced out of this pocket through a gate in one side of the lower end of the approach. In order to facilitate this sluicing the opposite side of the approach is built on a curve which throws the force of the stream through the gate when the latter is open.

Some of the clay and fine sand are not interrupted in this basin, and a certain amount of sand may be blown, or will fall into the canal. Provisions are made to remove most of these materials from the water by means of sand boxes built in the bottoms of the flumes which carry the canal over the water-courses that are crossed. These boxes are merely depressions in the bottom of the flume and are placed at intervals of approximately three-quarters of a mile. Each box is arranged with a sluice gate in order that the sand and debris that collects in it may be removed easily.

A settling basin, 18 x 50 ft. in plan and 9 ft. deep, is placed about 300 ft. upstream from the lower end of the canal to finally remove all the grit that is carried in the water. The water enters this basin through a grizzley of iron bars placed across the canal at a 30-deg. angle. These bars are spaced 2 in. apart so they interrupt practically all floating matter. The lower end of the bars is 1 ft. above the bottom of the canal, thus permitting sand and gravel to flow along into the basin.

The basin is built by diverging one side of the canal, and is lined with rubble masonry laid in cement mortar. The bottom drops away from the canal bottom gradually to a depth of 9 ft., the downstream end of the basin being vertical up to the level of the canal. The materials deposited in the basin are flushed out through a sluice gate placed in the downstream end of the outer side of the basin. The opposite side of the basin is curved toward the gate to induce a current toward the latter, which delivers into a natural water course.

The side hill above the station is so steep that no space was available at the end of the canal for a forebay large enough to provide for fluctuations of flow due to different demands for water in the station, or to other causes. This condition is overcome by two automatically-tripped flash boards on the crest of the downhill side of the settling basin. These boards are each 2 ft. high and 10 ft. long, providing a 20-ft. waterway. They are each on a horizontal pivot, placed eccentrically, so they will turn and permit water to escape when the level in the basin exceeds a predetermined height. Each board carries on the inner side a T-rail counterweight, attached to brackets, to govern the time of the operation of the boards and to cause the latter to return to their normal upright position at the desired time. The brackets are arranged so they can be shifted vertically and the rails can be moved horizontally on them, making the height of water at which the boards turn capable of variation. These flash boards serve effectually the purpose of a long spillway.

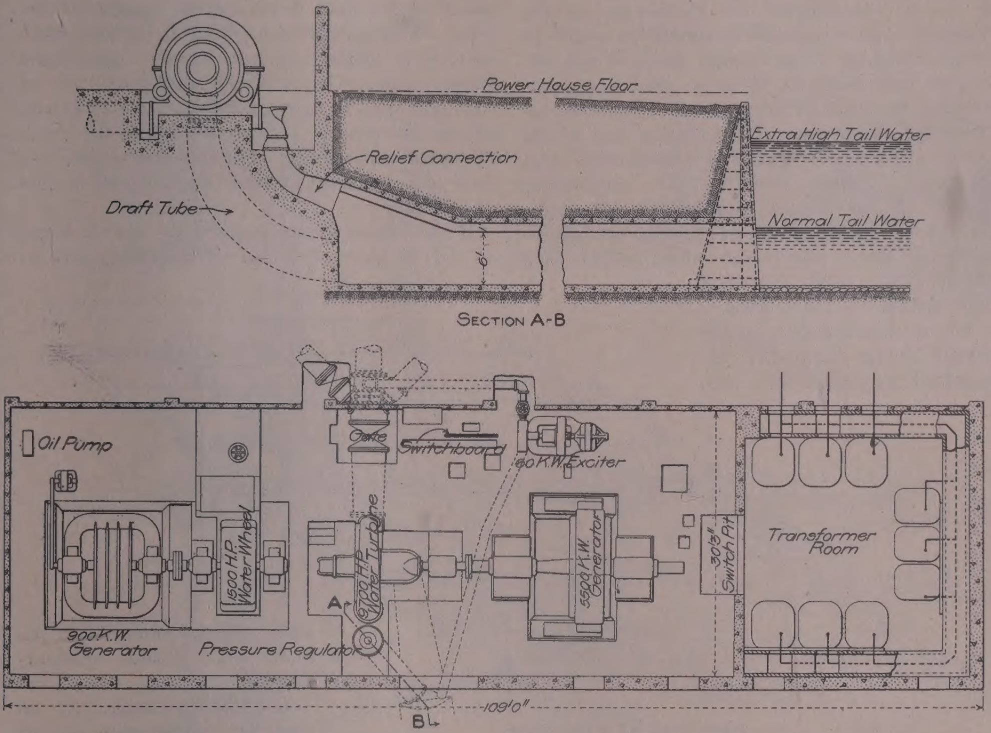
Three steel-pipe pressure lines lead from the end of the canal down to the power station. The upper ends of these lines open in a reinforced-concrete forebay, 18 x 25 ft. in plan, that has its bottom on a slope of about 60 deg. with the horizontal, corresponding with the slope of the hill-side and giving it a depth of 23 ft. at the downstream end. Two walls are built normal to that end on the inside of the forebay to separate the connections in the latter to the pressure lines. These connections are made trumpet-shaped to accelerate the water gradually and reduce the entrance losses.

The Centerville station was originally installed to supply power to mines in the vicinity, and at first contained a 400-kw. generator, direct-connected to a tangential water wheel. A 900-kw. 60-cycle 2,300-volt Stanley generator, direct-connected to a 1,500-h.-p. Doble tangential water wheel, was afterward added to the station. The 400-kw. unit was removed at the time the large turbine was recently installed. As the result of the increase in capacity at different times, the three pressure lines have been laid to convey the water from the end of the canal to the generating station, all three of which lines were built separately to meet the increases in the capacity of the station. These pipes, one of which is 42 in. and the other two each 24 in. in diameter, are 2,565 ft. long and are laid down the side of the mountain which rises quite abruptly above the station building. They are all of riveted steel, the thickness of the plates of which they are built being varied with the difference in head. The upper ends of the three pipes are each controlled separately by means of a gate valve at the forebay. The lower ends of the pipes are joined at the rear of the station building by a three-way connection. A gate valve is placed in each pipe just back of this junction so any pipe may be cut out of service without interfering with the other two.

The station building is approximately 30 x 109 ft. in plan in the clear, with the eaves line 20 ft. above the operating floor, as shown in an accompanying illustration. The building stands on a bench cut in the side of a solid sandstone ledge, the rear wall of the building abutting against the vertical face of this cut. The generating units are placed directly on the bed rock, to which they are anchored. The side walls of the building are of concrete and the roof is of galvanized iron, carried by steel trusses, making the structure fire-proof. The interior of the building is divided by a partial transverse partition wall into a generator room and a transformer room. A 16 x 30-ft. work shop is located at the opposite end of the building from the transformer room.

The arrangement of the two main units and the auxiliary equipment is also shown in the accompanying illustrations. The 9,700-hp. turbine was designed and built by the Allis-Chalmers Co., and is direct-connected to a 5,500-kw. 60-cycle 3-phase 2,300-volt alternating-current generator, built by the Stanley Electric Mfg. Co. The turbine is of the single horizontal type, with a spiral casing and a single quarter-turn discharge. It was designed to deliver 9,700 brake horse power, when operating at 400 r.p.m. under an effective head of 550 ft. The turbine consists essentially of an outer spiral casing containing a speed ring and a speed gate placed concentrically around the runner. As the casing, speed ring and speed gate compose that part of the turbine subjected to a hydrostatic pressure due to the head, and during sudden changes of load to even higher pressures, they are designed substantially, being built practically as a unit.

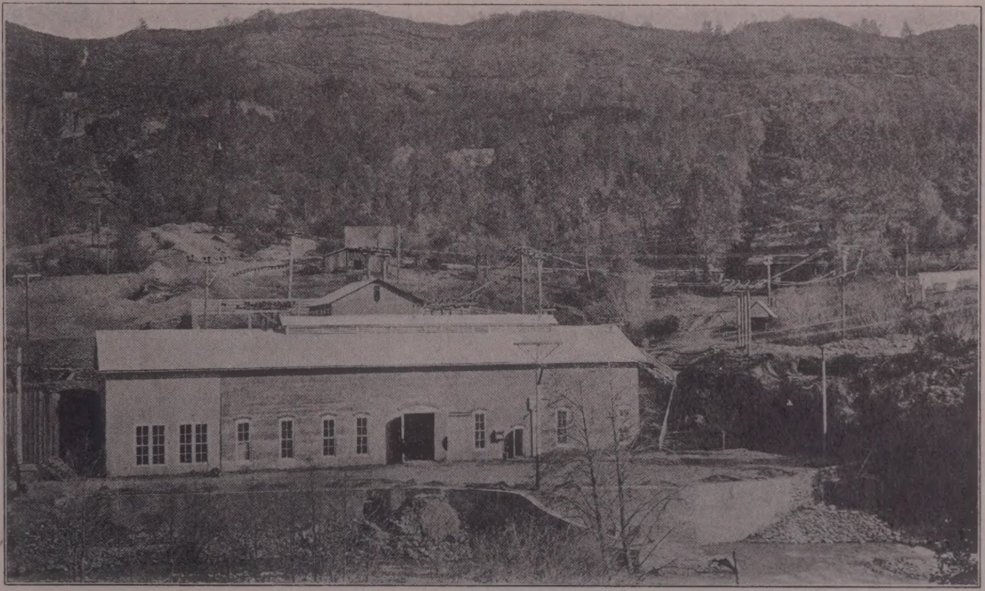
The speed ring is arranged to apply water to the runner as from a continuous nozzle extending around the latter. The casing, which is the heaviest part of the turbine, is made spiral in order to decrease gradually the effective intake area as the water is admitted through the speed ring and the speed gate. Since the speed ring is arranged as a continuous nozzle, it is designed to bring the velocity of the water to that acquired in the guide vanes of the speed gate. The latter consists of two concentric guide rings, with a series of pivoted guide vanes between them. Each guide vane is separately pivoted and, with its pivot, is forged in one piece from a single ingot. The pivots each pass through a packing box to the outside of the wheel casing, where they are connected to a shifting ring by means of levers and links. Both ends of the pivots are carried in cast-iron bearing glands, lubrication being provided through channels in the guides and by a pressure grease cup on the back of each pivot. The amount of water admitted to the runner is controlled by the position of the shifting ring. A type Q Lombard water wheel governor is connected to the shifting ring to regulate the speed of the unit, which will not be varied with changes in the demands on the system for power, since the transmission system to which the generator delivers is regulated entirely from another development.



Plan and Section through Draft-tube of Centerville Power Station.

The runner of the turbine is in a chamber inside the speed gate, and consists of a solid steel casting securely doweled and keyed to a horizontal shaft. The runner is designed to have sufficient strength to withstand a runaway speed and to have its maximum efficiency at the normal load of the generator. The discharge from the runner passes through an inner case ring, which is flared to reduce the velocity of the water as it leaves the runner. The water passes from this ring into a quarter turn leading to the draft tube. A pressure regulator is also provided in a relief waste connection between the casing and the draft tube to prevent excess pressures in the system.

The runner shaft is a solid steel forging, bossed to receive the runner, and with a flanged coupling forged on the generator end. The turbine has a main bearing of the generator type and an outside thrust bearing of the cantilever type. The thrust bearing can carry the total thrust of the turbine, but the runner is so balanced that the only appreciable thrust experienced is small amounts occurring when sudden load changes take place. The quarter-turn of the discharge and the outside thrust bearing are on a heavy base plate secured to the wheel case.



The Centerville Hydro-Electric Power Plant.

The spiral case of the turbine is divided along the horizontal center line in order that the upper half may be removed, making the working parts accessible without disturbing the bearings. In addition to the openings in the casing for inlet, pressure regulator and discharge connections, manholes are provided so the runner, guide vanes and all of the moving parts may be removed from the end opposite the discharge, without disturbing the main casing. The design of the speed ring is also such that it may be removed from the casing on the side opposite from the generator, without disturbing the casing.

The shaft of the 5,500-kw. generator is a solid forging, with a flange forged on the turbine end to form the connection with the flange on the turbine shaft. Excitation current for this generator is furnished by a 60-kw. 125-volt direct-current generator. The shaft of this exciter is arranged so it may be driven by an induction motor, or by an 85-h.-p. tangential water wheel, supplied with water from a connection with the main pressure line.

The transformer room contains one bank of three 380-kw. oil-cooled transformers and two banks each containing three 840-kw. oil-cooled transformers. The operation of the main unit is controlled through General Electric oil switches on a two panel switchboard against the rear wall. These switches are operated from a pit in the floor of the room near the entrance to the transformer room, by means of a system of links and levers placed in a covered trough in the floor.

The high-tension out-going bus-bars to which the secondary side of the transformers is connected are in turn connected with lines leading out of the building to a separate switching station immediately back of, and above the main building. The transmission lines coming from the de Sable station are controlled in this switching station, and the latter provides means whereby the output of the Centerville development can be delivered to any of three transmission lines leading from that point.

When this description was prepared the high-head turbine had been in continuous service for about three months. During that time preliminary tests of the unit demonstrated that the efficiency guarantee of the turbine maker had been satisfactorily fulfilled. As the California Gas & Electric Corporation is expecting to make more exhaustive tests of the unit, the results of the preliminary tests have not been made public.

The hydraulic work and the station were constructed under the direction of Mr. J. H. Wise, assistant hydraulic engineer for the California Gas & Electric Corporation. The station apparatus was installed and placed in service under the direction of Mr. C. F. Adams, assistant electrical engineer for the corporation.

Electrically-Driven Rolling Mills are operated now at eleven works on the Continent and at one in Great Britain.

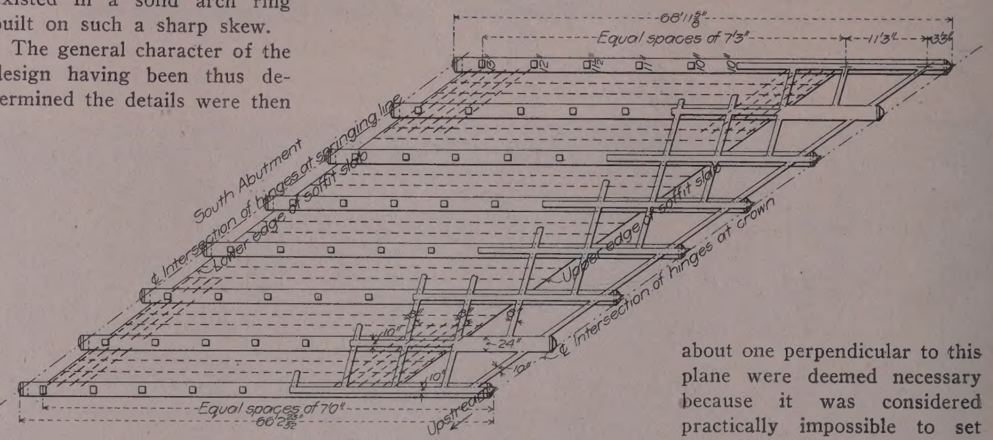
A Three-Hinge Reinforced-Concrete Skew Arch Bridge in Denver, Col.

A three-hinge reinforced-concrete skew arch bridge involving numerous special features of design has recently been completed to carry Bannock St. over Cherry Creek in Denver, Colorado. This creek has its source in the foot-hills south of the city, and flows generally northward to its confluence with the Platte River near the central business district. The stream winds about irregularly in the comparatively flat valley through which it passes, and, although it is subject to excessive floods, during the greater portion of the year it carries only a small quantity of water, which flows in a constantly shifting channel in the loose sand that forms its bed. The land adjacent to that part of the creek within the city has not been improved to any extent until recently on account of the existing conditions. Within the past year, however, a regular definite channel has been completed up to about 1.5 miles from the mouth of the stream by building two parallel reinforced-concrete retaining walls, 80 ft. apart. This channel improvement work was described in The Engineering Record of Feb. 15, 1908. The plans under which the work was done include the continuation of the retaining walls for another mile, the re-grading of the land adjacent to the walls so it will be suitable for streets and buildings and the construction of a boulevard drive along the right bank of the creek, upstream from Bannock St. for some distance. All of these plans are being executed as rapidly as possible and new bridges to carry the streets over the creek are being constructed where necessary. Bannock St. was originally carried over the creek by a through-truss steel bridge of two spans of 100 ft. each, having a 20-ft. roadway with a 6-ft. sidewalk on each side. This bridge was replaced by the concrete bridge because its carrying capacity was insufficient and its appearance was unsuited to the improved surroundings.

On account of the location of the Bannock St. crossing a new bridge structure of pleasing design was particularly desirable. The decision was therefore made to build a concrete arch bridge, since this type was considered to be most readily adapted to the existing conditions and the desired results. The center line of the street at the crossing is at an angle of approximately 36 deg. with the center line of the creek channel as defined by the retaining walls along the latter. The creek channel is also on a curve with a radius of 2,720 ft. at the crossing, which, with the acute skew, required a span of 132.5 ft. on the upstream side of the street while the span on the downstream side was 138 ft. A uniform rise could be obtained, however, for all parts of the arch. Under these conditions it was desired to build a bridge to carry a 36-ft. roadway with an 8-ft. sidewalk on each side. The structure was required to carry a live load of 150 lb. per square foot of the roadway and sidewalks; this load to be uniformly distributed over the entire span, or over any portion of it. The floor system also had to be designed to carry this uniform live load or a 20-ton road roller. The maximum allowable compression on the concrete was 600 lb. per square inch, while the tension in the concrete was disregarded. The greatest tension allowable in steel reinforcement was 16,000 lb. per square inch.

The general conditions of the design were therefore clearly determined. At the same time, the designer had no confidence in the ordinary theory of skew arches, and the time available to prepare the plans was insufficient to make the study necessary to develop a rational theory. Moreover, the designer had determined by previous analyses of masonry arches having about the same rise and span as the one to be built that the temperature stresses were large enough to require a very heavy arch ring. The necessary ring was so heavy, in fact, that it was considered impossible to attempt to lighten the appearance of the spandrels. The limited head-room available required a very flat arch, having its springing lines nearly at the established line of the sand surface between the retaining walls of the creek channel. Such an arch, together with solid spandrels nearly flush with both edges of the arch ring, would have appeared more as a dam through which a hole had been broken than as a bridge spanning a stream. As open spandrels would relieve this appearance and also increase the area available for the passage of floods, they were accordingly used. The desire to secure as light an arch ring as possible necessitated the elimination of the temperature stresses, which elimination could be accomplished by using hinges. Since it was obviously impossible to hinge a solid ring constructed on such an acute skew as existed between the center lines of the channel and of the street at the crossing, rib construction was adopted. Besides avoiding the temperature stresses, the rib construction is considered to have the further advantage of overcoming the uncertainty of stress distribution which would have existed in a solid arch ring built on such a sharp skew.

The general character of the design having been thus determined the details were then developed. Eight reinforced-concrete ribs were employed instead of a solid arch ring, each rib being hinged at both abutments and at the center. In estimating it was determined that the total weight of the structure was almost uniformly distributed along the horizontal, so each rib was built as a parabola, with a rise of 13 ft. and a span of 132.5 ft. to 138 ft., depending on the position of the rib. Dead load bending moments were thus avoided. The bending moments due to a full live load on one side of the hinges at the center were then calculated in order to determine the extreme position in the arch ring of the line of pressures. This line was found to be contained entirely within the middle third of the depth of the ribs, so no tension exists in any part of the rib sections.


68'11⅝"
Equal spaces of 7'3"
11'3"
3'3⅝"
South Abutment
℄ Intersection of hinges at springing line
Lower edge of soffit slab
Upper edge of soffit slab
℄ Intersection of hinges at crown
10"
24"
10"
19"
Equal spaces of 7'0"
66'2 23/32"
Upstream

Half Plan of Arch Ribs.

The eight ribs have, in general, the same cross section at corresponding points in them and are all reinforced in the same manner. The details of one-half of one rib are shown in an accompanying illustration, the two halves of each rib being symmetrical. The ribs are uniformly 24 in. wide, but vary in depth at different points as is required to confine the line of pressures within the middle third of the depth. Each rib has a maximum depth of about 40 in. close to midway between the abutment and center hinges, and decreases gradually in depth from this maximum point toward both hinges, the depth at the abutment hinge being 27 in. and at the center hinge, 24 in. Each rib is reinforced with twelve continuous 1¼-in. square bars, about 70 ft. long, which are in two horizontal planes, one 2.5 in. from the intrados containing six of the bars, and the second the same distance from the extrados containing the other six. These bars are all spaced 3¾ in. apart on centers in the horizontal rows and have both ends fitted into the cast-steel shoes on which the hinges of the half of the rib are mounted. The bars in the two rows are fastened together at different intervals, as shown in the accompanying illustration, by sets of six ¼-in. round rods properly hooked over them to insure unity of action. Four 1-in. square bars, 35 ft. long, were also placed midway in each rib, two of these bars being in the same plane, 2½ in. above the plane of the lower six 1¼-in. bars, and the other two the same distance below the upper bars.

The steel in the ribs simply takes the place of a certain amount of concrete, thus reducing the cross section and, therefore, the weight of the ribs. As no part of the section of the ribs, however, is in tension the bars receive compression stresses only. The relatively large proportion of steel was used to increase the moments of inertia of the rib sections without increasing the depth of the ribs excessively. For this reason, also, the steel was concentrated near the top and bottom of the rib.

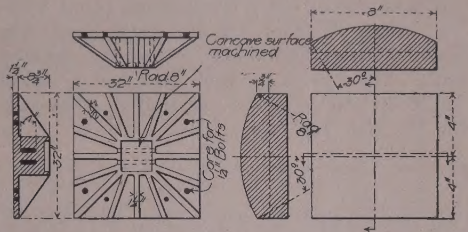
Hinges which would permit some motion about an axis lying in the plane of the rib as well as about one perpendicular to this plane were deemed necessary because it was considered practically impossible to set pins for hinges with exactly parallel axes. Consequently, rocker plates were substituted for the pins. Each hinge has two heavy cast-steel shoes, against which these rocker plates take bearing. At the abutments one shoe of each hinge is anchored by a pair of 1⅛-in. round U-bolts set 3 ft. 9 in. back into the concrete of the abutment. The other shoe of each of these hinges is built with a depression 3 in. deep in its rear face and was set so the concrete and steel at the end of the rib on which it is carried could be placed in this depression.

The rocker plate is between the two shoes set in this manner. One face of the rocker plate is machined and polished to the arc of a cylindrical surface having an 8-in. radius, with the axis of the cylinder horizontal; the other face is finished in the same manner, except the axis of the cylinder is in a vertical plane containing the axis of the arch rib. Each face of the plate bears on a concave machined and polished surface in the shoe, which surface has its axis parallel with that of the corresponding face. The hinges at the center between the halves of the ribs are also built in the same manner, except that both shoes of each hinge are carried on the ends of the halves of the ribs by making the base of each shoe so the concrete and steel of the rib can be placed in it. A joint which permits vertical and horizontal motion in the ribs is thus secured at each hinge.

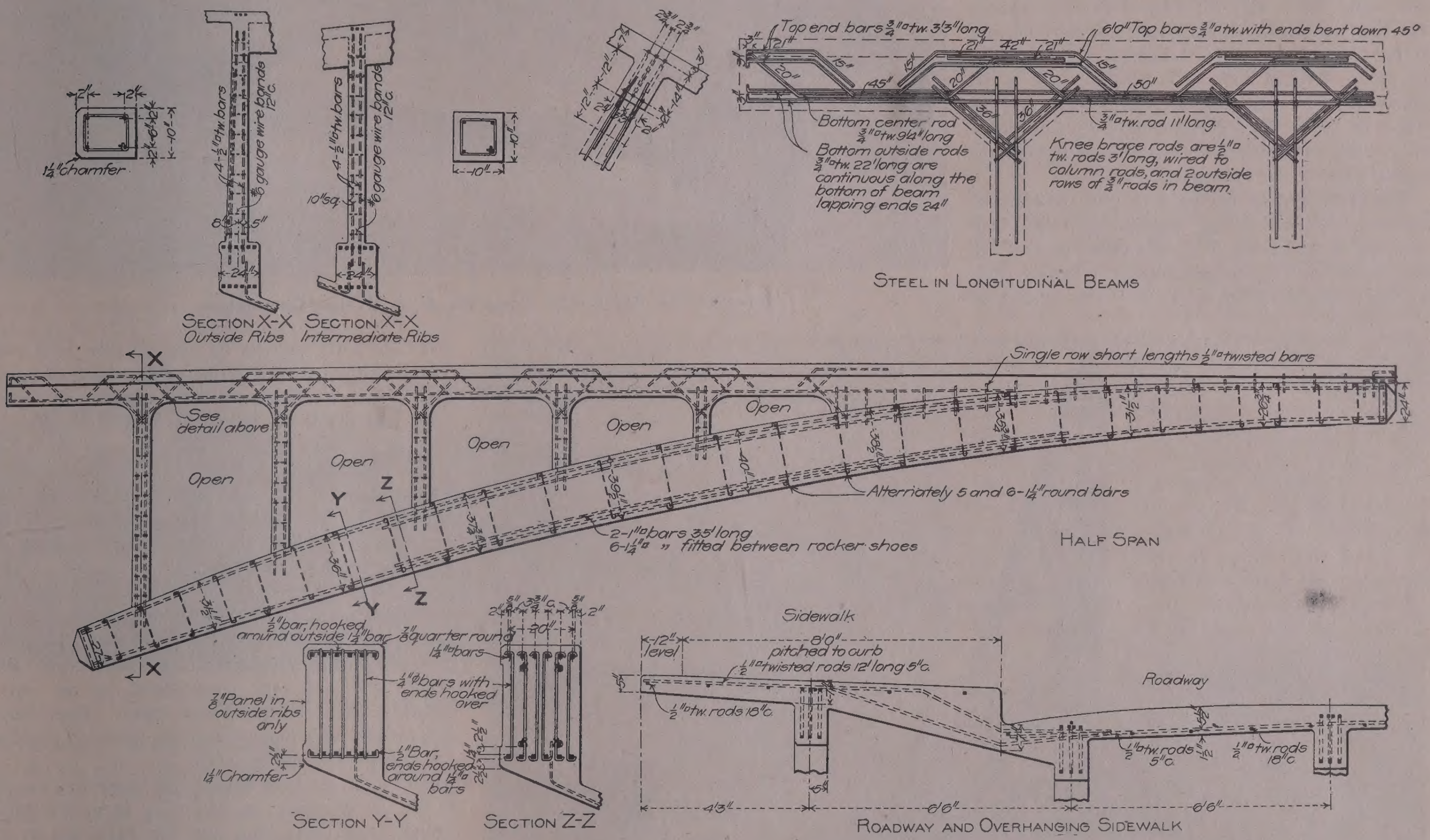
Four ¾-in. bolts were used to fasten the pair of shoes at each hinge together until the concrete of the ribs had been placed and had set. These bolts, which insured the rocker plates to be squarely seated, were cut out before the centers on which the forms for the arch ribs were erected had been struck. Even with this arrangement the hinge shoes at the skewbacks were properly set with much difficulty and proved the wisdom of using the rocker plates instead of pins in the hinges.

The abutments of the arch are of the hollow ribbed type, consisting simply of thin reinforced-concrete retaining walls, with heavy buttresses on a broad reinforced-concrete footing. The faces of the abutments were built to conform to the curve and batter of the retaining walls confining the creek channel. One buttress was built as an abutment to each arch rib, the axes of the corresponding abutments and ribs being coincident. The adopted type of abutments was used simply to reduce the quantity of concrete. Since cement cost $2.30 per barrel, gravel $1.50 per cubic yard and common labor $2.25 per day, concrete was an unnecessarily expensive material to serve no purpose except that of a dead weight such as it would in a monolithic abutment.

Each buttress of the abutments is 18 in. wide and 27 ft. long at the base, where it rests on a row of nine piles. The rear six of these piles in each set of nine were driven on a batter of 1 to 3, inclined toward the center of the arch. White oak piles not less than 12 in. in diameter at the butt or 8 in. at the point and from 22 to 26 ft. long were used. These piles were driven until they did not sink more than 5 in. under ten successive blows of a 2,000-lb. hammer falling 25 ft. In the case of the piles driven on a batter, the vertical fall of the hammer, less an arbitrary deduction of 2 ft. to allow for the increased friction in the guides of the pile driver, was used in determining the required penetration. When the fall of the hammer was different from 25 ft. the penetration was required to be such as would give the same bearing power as the above specification by the formula, $P = 2Wh \div (S + 1)$, in

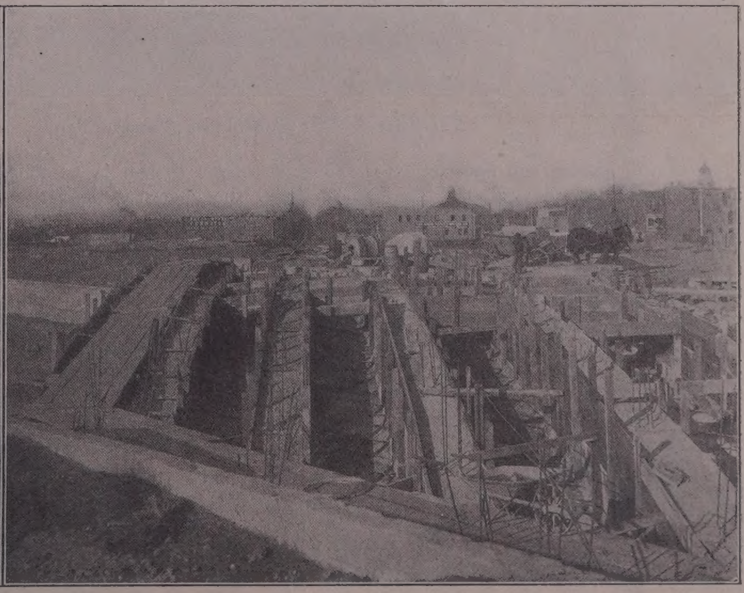


Shoe and Rocker Plates.


1¼" Chamfer
Section X-X Outside Ribs
Section X-X Intermediate Ribs
Steel in Longitudinal Beams
Top end bars ¾" tw. 3'3" long
6'0" Top bars ¾" tw. with ends bent down 45°
Bottom center rod ¾" tw. 9'4" long
Bottom outside rods ¾" tw. 22' long are continuous along the bottom of beam lapping ends 24"
¾" tw. rod 11' long
Knee brace rods are ½" tw. rods 3' long, wired to column rods, and 2 outside rows of ¾" rods in beam.
Single row short lengths ½" tw. twisted bars
See detail above
Open
Alternately 5 and 6-1¼" round bars
2-1" bars 35' long
6-1¼" " fitted between rocker shoes
Half Span
Section Y-Y
Section Z-Z
Sidewalk
Roadway
Roadway and Overhanging Sidewalk

Details of Reinforcement in Ribs, Columns, Beams and Floor.

Forms for Beams and Girders.

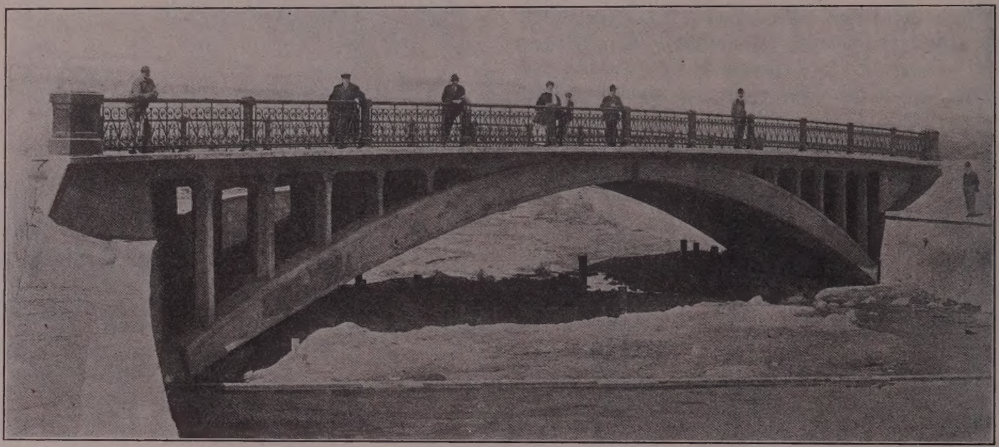


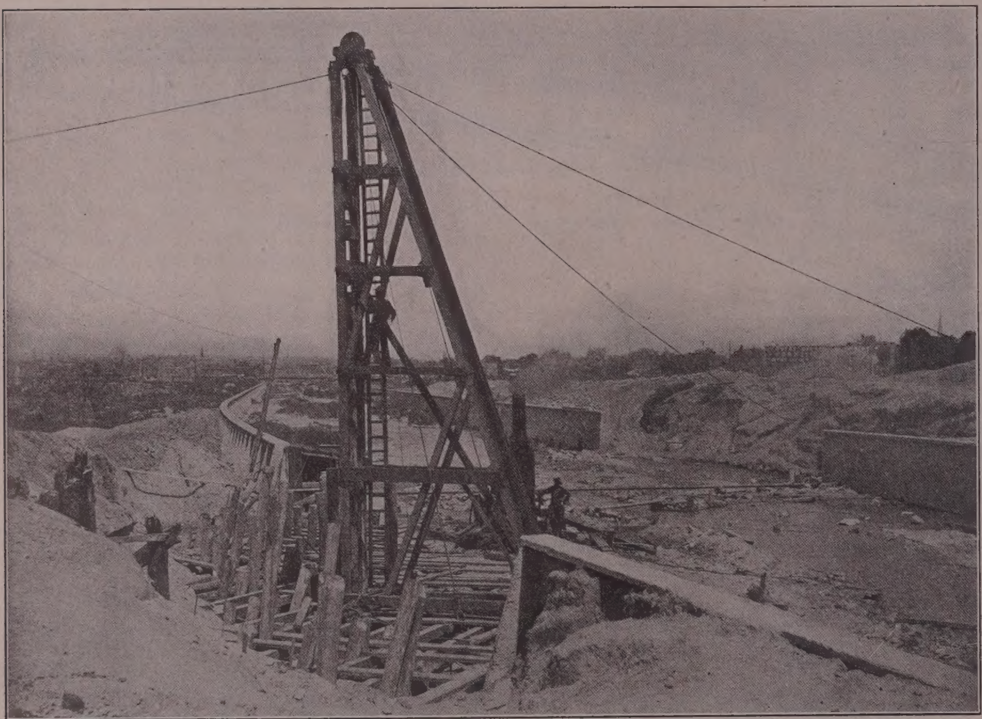
Completed Arch Ribs.

which W is the weight of the hammer, h is the fall in feet and S is the penetration per blow in inches. The excavation for the abutments was completed before the piles were driven, but the total penetrations in most cases were from 15 to 18 ft. Some of the piles, however, could not be driven more than 10 ft., while a few reached the extreme of 25 ft.

In order to secure the requisite lateral stability of the arch ribs a 5-in. reinforced concrete soffit slab was placed between the ribs. The bars used to reinforce this slab are bent up at the ends into the arch ribs in order to secure continuous action. The slab was omitted for 13.5 ft. on both sides of the transverse center line of the arch so the forms required in building the floor system could be removed. With the exception of this open central portion, the appearance of the arch from beneath is the same as that of a solid arch ring. The soffit has a slightly warped surface because the abutments are neither plane nor parallel, nor is the line of the crown hinges straight, but the departure from a truly cylindrical surface is not apparent. The sidewalks are cantilevered and the edges of the walks are surmounted by iron handrails, both of which features tend to lighten the appearance of the structure.

The floor of the bridge is a 7-in. reinforced-concrete slab, carried by longitudinal reinforced-concrete floor beams and transverse girders, all supported on reinforced-concrete columns built on the extrados of the arch ribs. The spacing of the columns, girders and floor beams is shown in an accompanying illustration. The longitudinal rows of columns on the ribs are spaced transversely in such a manner that they are also in regular transverse rows, parallel with the axis of the stream channel. They thus form open spandrels which greatly improve the appearance of the bridge, and add much to the water-way capacity for carrying flood flows.


Three-Hinge Reinforced Concrete Arch Bridge Completed.


Condition of Site at Starting Construction.

With the exception of the columns in the two outside longitudinal rows, the columns are 10 x 10 in. in cross section and are each reinforced with four ½-in. square bars placed vertically and tied together with wire at intervals of 12 in. The columns in the outside rows are similarly reinforced, but are 10 x 13 in. in cross section at the bottom and have champfered outer edges. The reinforcement bars are carried down into the concrete of the arch ribs and up into the floor girders to produce continuous action. The beams and girders are reinforced as shown in the accompanying detail drawing. The 7-in. floor slab is reinforced with ½-in. twisted square bars spaced 5 in. apart on centers for the transverse bars and 18 in. for the longitudinal bars.

A thickness of heavy tarred paper forms a true joint where the floor slab and longitudinal floor beams take bearing on the tops of the abutment walls. The tops of the walls also have a smooth surface at this joint and are built to form seats for the slab and beams. The concrete of the floor system is extended out over the face of the hinges at the crown, but a joint ¾ in. wide at the base and ⅜ in. wide at the top of the slab is left in the slab at the hinges. The floor is thus given an opportunity to respond to changes of position due to variations of temperature, or other causes.

It was deemed necessary to give the floor of the bridge a quite heavy camber in order to avoid the appearance of a depression at the middle of the span. This camber was fixed at 15 in. and the roadway was given at a transverse crown of 9 in. A tendency to produce a badly warped roadway surface was introduced by the combination of the acute skew of the span, the heavy camber and transverse crown of the roadway, the obvious necessity for keeping the apex of the camber curve at the middle of the length of each sidewalk and the necessary grade of the approaches to the bridge. This extreme condition was mitigated somewhat by increasing the transverse slope of the sidewalk from ⅛ in. to the foot at one end of the bridge to ½ in. to the foot at the other end, the standard in Denver being ¼ in. to the foot. The face of the curb was also permitted to increase in width from 5¼ in. at one end to 11¼ in. at the other end and the two gutters have different elevations at correspondingly opposite points. The appearance of the roadway surface finished in this manner is very satisfactory.

The 8-ft. sidewalks on both sides of the roadway are each carried by the outside arch rib. The longitudinal center line of the rib is in each case 4 ft. 3 in. from the outer edge of the sidewalk and the latter is cantilevered from the rib to that amount. The reinforcement in the sidewalks is arranged to provide for this cantilever and to carry a light ornamental-iron hand rail along the outer edge of walk in addition to the regular live load. This hand rail as designed is not only in keeping with the remainder of the bridge, but lends much to the appearance of the structure. All of the posts of the rail are hollow cast iron; the newel posts are sufficiently large to give the proper weight to the portals of the bridge and are each surmounted by an ornamental cluster of incandescent lamps. Each hand rail is built with three expansion joints to provide for the motion of the arch.

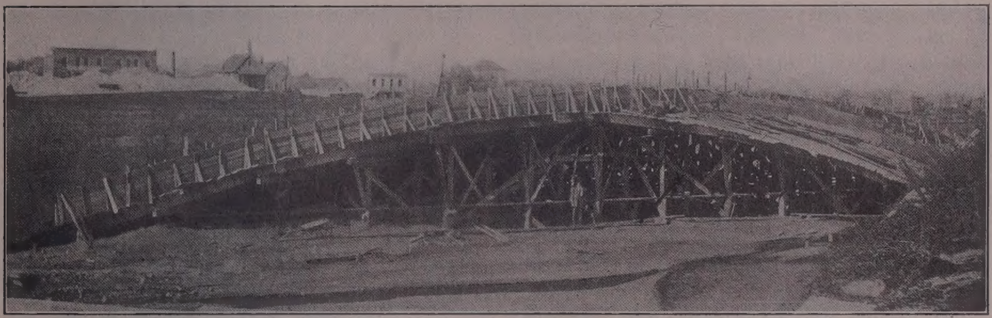
All of the concrete used in the work was mixed in the proportions of one part Ideal Portland cement, two parts sand and five parts gravel or broken stone. Crushed granite was used in the arch ribs and gravel in all other parts of the bridge. Twisted square bars were used for reinforcement, except the square bars used in the arch ribs. The 1¼-in. bars required for the rib reinforcement were not obtainable in lengths of more than 30 ft., while bars approximately 70 ft. long were required. The shorter lengths were therefore butt-welded electrically. Alternating current was obtained from a local distributing circuit and was stepped down by a transformer set up close to the bridge site. The welded joints thus made were strong enough to break the body of the bar. The welding could also be done for less money than any other method of connecting the bars; in fact, it was even cheaper than the cost of the extra steel required to simply lap the bars in place. After being welded, the bars were cut to the proper length for the ribs in which they were to be placed by a power hack saw. The welding and cutting were readily done as rapidly as the bars could be set in position in the forms so no delay resulted.

The total quantity of concrete in the entire structure is 1,146 cu. yd. The bridge contains 83 tons of reinforcing steel and 33,000 lb. of steel castings. The total dead weight carried by the arch ribs is 1,150 tons, and the live-load carrying capacity is 535 tons, a ratio of 2.15 to 1, whereas the usual ratio for bridges with solid arch rings and an earth fill between the spandrels is 5 or 6 to 1. The bridge weighs 320 lb. per square foot of floor surface.

The contract price for the bridge was $27,950 and the contractor was allowed an extra of $375 to cover the cost of some minor changes which were deemed advisable during the progress of the work, thus making the cost of the finished structure to the city $28,325, or $3.98 per square foot of floor surface. This cost includes a concrete pavement for the roadway. This type of pavement has been used on certain bridges and at some street intersections in Denver where traffic is very heavy and has been found to be more durable and more satisfactory than any other type of pavement yet tried.

Construction.—The concrete retaining walls on both sides of the channel had been built at the site of the bridge before the type of the latter was decided. These walls, therefore, had to be removed before the excavations for the abutments could be made and the piles driven. A 2,000-lb. drop hammer operating in 40-ft. guyed leads and handled by a double drum hoisting engine was used in sinking the piles. As soon as the latter had been driven, the abutments were both built. Then the falsework piles were driven and the centering for the arch ribs and the soffit slab were erected.

The falsework piles were driven in regular rows under the arch ribs, the piles in the rows being from 9 ft. 5 in. to 9 ft. 8½ in. apart on centers.



Falsework and Centering for Arch Ribs.

Each row of piles was capped with a 3 x 8-in. plank, on which was erected a 6 x 6-in. post at each pile. The transverse rows of posts were capped in turn with a 3 x 8-in. plank. The centering for the ribs consisted of 3 x 14-in. joists, spaced 1.5 ft. under the ribs and 2.5 ft. elsewhere across the arch and cut to the proper curve. These joists were replaced on 6 x 8-in. transverse girders, blocked up from the caps on the posts with wedges, and were lagged with 2 x 8-in. planks dressed on one side and both edges. The falsework and centering was all cross- and sway-braced thoroughly.

The forms for the arch ribs were built up on the centering, and the reinforcement for the arch ribs and the soffit slab all erected in place before any concrete had been placed in the arch proper. The shoes of the hinges at the skewbacks were placed in the abutments when the latter were built. The shoes on the ends of the ribs at the skewbacks could then be set in their proper position and the rib forms built around them, the shoes of the hinges at the crown of the arch also being set as the rib forms were built. The reinforcement bars in the ribs were then assembled in the forms in such manner as to insure that they would retain their position when the concrete was poured. The ends of these bars were also placed in the depressions in the base of the hinge shoes so they took bearing on the base of the shoes.

The concrete was mixed in two concrete mixers, one of which was set up on each side of the site, so the concrete could be wheeled to place readily. The concreting of the last arch rib was completed on Nov. 14 last, and the rib centers were struck on Nov. 30. The greatest settlement at the crown of any rib at the time the centers were struck was 0.075 ft. and the least was 0.01 ft. The centers were built with an excess camber of 2 in. to provide for settlement, which, however, was less than was anticipated. With the ribs carrying their own weight, the forms for the columns, beams and girders of the floor system were built and these members were concreted. Then the floor slab was cast and the roadway and sidewalks were finished, the forms being removed two weeks after the last concrete had been placed.

The bridge was designed by Charles W. Comstock, M. Am. Soc. C. E., consulting engineer, and constructed under the general supervision of the consulting engineer and of Mr. John B. Hunter, city engineer. Mr. George M. Post was resident engineer on the work. The contractor was the Commonwealth Construction Co., of which the late Mr. A. I. Gray was president; Mr. F. C. Dreher is vice-president and engineer, and Mr. W. H. Decker, secretary and treasurer of the company.

Sewage in Condensers.

Sewage water will be used for condensing purposes by a new arrangement nearing completion in the McDonald Road electric light power station of the city of Edinburgh. A main sewer near the power station was tapped through a shaft 26 ft. in diameter and 35 ft. deep. The sewer was cut and a suction pit constructed about 3 ft. below the invert, a weir being placed across the chamber to intercept the flow. The water is passed through copper wire screens into the suction pit and is pumped through four 18-in. pipes to the condensers, from which it is returned through a 26-in. pipe to the shaft and is discharged into a chest 4 ft. square. There the water is agitated by means of plates to get rid of foul gases and is passed into an outlet chamber and thence into the sewer. Any gases that may be generated will be pumped by two motor-pumps back to the power station, where they will be consumed in the furnaces. The weir to dam the water will not require to be used when the sewers are in flood. The work of construction has only occupied five months, whereas any of the other schemes suggested would have taken 12 months at least.

AN OIL-ENGINE LIGHTING STATION has been installed by the Borough of Pennsburg, Pa., near Philadelphia, for street and commercial lighting service. The equipment consists of two horizontal 2-cylinder, 2-cycle engines, of 50 and 70-h.-p. capacity, respectively, which were built by Mietz & Weiss, New York, and operate with fuel distillate, costing 4 to 5 cents per gallon in tank car lots. The engines, which are each belted to a 35-kw. alternator, are started with compressed air and consume on the average 1 pint of oil per horse-power-hour when approximately fully loaded.

The Selection of Coal.

The selection of steam coal for many large power plants in New England has received special attention for many years, owing to high transportation charges making the fuel bills particularly heavy in that part of the country. The chemical engineering laboratory of Mr. A. D. Little, of Boston, has made fuel examinations for many purchasers, and the chief of its coal testing department, Mr. E. G. Bailey, recently read a paper before the New England Street Railway Club in which he gave conclusions from certain features of his experience in such work.

There are many different methods of buying coal to-day employed and some of them are somewhat antiquated. Some people buy coal simply because the price is the cheapest they have had quoted to them. Another man buys coal upon its past reputation. Another takes the recommendation of his engineer or fireman, no matter what the price. Another man buys his coal upon the basis of the highest number of heat units per dollar. Another will make evaporative tests and buy the coal giving the highest evaporation per dollar. Of course the latter result is what everyone wants in a steam plant, but in such cases the purchaser is frequently misled, because he figures the price of his coal f.o.b. the car or vessel and does not consider that a coal which may evaporate 8 lb. of water to a pound of coal costs a good deal more to handle enough to supply him for a year, than if the coal evaporated 10½ lb. of water to a pound of coal. He has to pay more for labor for having the coal brought into his boiler room; he has more ashes, and all the way through there are numerous small expenses which, if considered in the first place, might show that coal to be more expensive at the end of the year than the other coal would have been.

It is incorrect to judge a coal on the basis of price, Mr. Bailey said, or on quality. There are certain practical things that must be considered, such as delivery and spontaneous combustion. There are numerous things upon which a definite money value cannot be placed, and each person must use his own judgment to a certain extent after all. There are variations in the conditions in the mines as impurities, sulphur balls; and also the preparation of the coal, so that what was received from a mine last year does not prove that the same will be received during the coming year. Moreover, a purchaser cannot drop the matter as soon as he has made his contract. He must follow the thing up to be sure that he is getting the value contracted for. He may determine this by inspection, and if the coal is from the same mine and of the same character, one can tell a great deal about the coal as to impurities, one of the largest factors in the question. He may make evaporative tests from time to time, and in that way determine whether the coal is giving the results previously obtained from it. He may analyze the coal, determine the percentage of ash, sulphur, and heat units. He may buy the coal on a B. t. u. basis.

The use of the thermal unit method has been much extended, and several large concerns are buying their coal in that manner. Its fault lies mostly in having to pay a higher price for the coal. The coal dealer is not sure his coal is going to run uniformly throughout the year, even from the same mine. He is going to have his profit and he therefore puts up the price from 10 to 25 cents to offset the chances of that coal being bad. If he can afford to take the risk at 25 cents a ton, why can't the buyer? There are certain cases where it is advisable to buy coal on a B. t. u. basis, but the coal man is not yet ready to do a general business on that basis. One reason why the coal man advances the price in order to offset any difference in quality is because he is not familiar with his own coal.

He has probably had a few analyses from it, but he is not sure they are the average. Another reason is that by past experience the sampling of coal delivered has been done in such a way that fair average results have not been obtained. Sometimes the coal man is cheated and sometimes the buyer.

A fair sample of the coal is a very difficult thing to obtain by a person who does not know all the chances for obtaining erroneous results, and that has knocked the confidence out of both the coal seller and buyer; but a proper average sample of coal can be obtained. There is a large concern which burns about a thousand tons of coal a day, and receives a coal which runs fairly uniform. From the results of their sample it seldom varies more than one-half of one per cent. in quality. They have learned that a few shovelfuls, or a handful here and there does not represent the average of a car-load; it is necessary to take a considerable quantity, from 500 to 2,000 lb. That should be taken miscellaneously, all of it broken up and thoroughly mixed, so that a piece of slate left in the sample or thrown away will make practically no difference. A small sample may have a piece of slate in it that will be 5 per cent. of the total. This is often found in samples taken, so it is easy to see where the discrepancy comes in.

The method of determining the quality of coal by evaporative tests is what may be considered the really practical method, but there are certain difficulties even there. The boiler efficiency varies with so many things that it is practically impossible to maintain the same boiler conditions throughout two consecutive tests. The fireman has a great deal to do with it; the load on the boiler, the draft, the cleanliness of the heating surface; all these things are very irregular. The method of determining heat units in a laboratory is a very practical one. A small amount of coal is taken, which is a representative sample if properly taken, and is burned in an atmosphere of oxygen in a steel bomb which is submerged in water. A very delicate thermometer gives the temperature of this water before the coal is burned, and by means of an electric spark the coal is ignited and entirely burned and every bit of the heat developed is absorbed by the water and the thermometer rises accordingly. From this rise in temperature the B. t. u. are determined. The result is practical and obviates all the errors which come in a practical boiler test.

There are a number of opinions regarding the various coals and the boiler efficiency possible to obtain from them, but Mr. Bailey thinks people have been misled by changes in the method of firing, etc., which have been responsible and not the quality of the coal. A fireman in making a series of tests of different kinds of coal cannot possibly do justice to each one of them, when they are of different character, by firing with one kind one day and another the next. He must learn how to handle the various coals in order to get the results which it is possible to obtain from them if he were firing them continuously.

In most boiler rooms, the thing of primary importance is to keep steam, regardless of efficiency. But in designing a plant or making changes, efficiency should be considered as well as the ability to keep steam. There are certain conditions where the boiler capacity is limited, the grate area is small, and the draft is not very strong, so that only the very best of coal can be burned. In such cases they must confine themselves to Pocahontas, New River, or Georges Creek coal, regardless of the price. But if the quality of coal coming into a market be sufficiently different and there is such difference in price that the cheaper coal would be a great saving at the end of the year, it will pay almost anyone to make decided changes in the boiler plant, if necessary, in order to take advantage of the coal which will give the most evaporation per dollar. Many people consider the cost of a plant of primary importance, but the fuel bill will eat up the price of a new plant practically every year, so that it only takes a difference of a few per cent. in waste, as far as boiler efficiency is concerned, to repay anybody for taking very decided steps in improving boiler conditions so they will be able to burn the cheapest fuel.

Although the plant may have been designed so it can handle the very poorest grade of coal coming into the market there are certain conditions entering which may prevent the owner from getting as high efficiency as from the best of coal. One of these is moisture. The higher the moisture in the coal, the less efficiency, because that moisture must be evaporated before the water in the boiler can be. This is of very little importance, except in cases of "crop" coal and in the Central States. In Ohio and Illinois, where the coal runs very high in moisture, this item is of considerable importance, as compared with the Eastern coals. The high volatile gives a chance for loss when burned under ordinary conditions. A furnace can be designed so that all of this is burned and little or no loss results from it. Take a boiler which gave good efficiency with anthracite coal and put a gas coal of 35 per cent. volatile in that furnace, and there will be a decided loss, because the hydro-carbons are cooled before they can become completely burned. It takes a longer time to mix those gases with the air, and if the temperature is reduced before that mixture is complete, the flame is extinguished and loss results. The Chicago Edison Co. has met this problem very successfully. The Illinois coal which they burn is high in ash and sulphur, and has many difficulties along the mechanical line to be considered. The volatile matter is very high and the question of unburned gases and smoke has been a considerable annoyance, not only to them but to other people in that district. They have now a furnace in which they have an abnormally large combustion chamber, and claim that there is practically no smoke.

Ash in coal is also a matter which affects the boiler efficiency. This depends not altogether upon the amount of ash, but upon the nature of it. Ash from certain coals has a very high fusing temperature. It is almost impossible to make any large clinker from it, no matter how much fire there is, while other coals at a comparatively low temperature (the fire not being forced) will give a very bad clinker. This has frequently been blamed on the sulphur. The sulphur itself should not take the blame, because it is a question of the fusibility of the ash. Ash in coal is composed of practically the same things as clay. Some of it contains considerable iron and other fluxes, which cause it to melt at a very low temperature and give a great deal of trouble in burning grates, stopping the air supply, necessitating frequent cleaning of the fire, which condition results in a lower boiler efficiency. Every time the fire is cleaned, the boiler is cooled and in order to obtain the previous furnace conditions, several hundred pounds of coal are required. Also, with a higher ash, whether clinkering or not, the fire must be cleaned more frequently, and the percentage of loss in the coke that drops through the grate is larger in proportion to the working of the fire and the number of times that it is cleaned.

Sulphur in coal is detrimental for two reasons. It is generally combined with iron, and the iron causes the clinker. The sulphur also, being liberated as the coal is burned, undoubtedly has some effect on the boiler tubes, the stack (if an iron stack is used) and the other iron work, but just to what extent this occurs Mr. Bailey had no specific data. In a case where horizontal return tubular boilers are used at mines which produce coal varying from 0.9 to 4.00 sulphur, there is no practical difference noted in the condition of the boilers. In another case, where low sulphur coal was burned, an analysis of soot and other accumulation on the outside of the tubes of a Babcock & Wilcox boiler showed nearly 25 per cent. of free sulphuric acid and sulphates of iron, showing that the tubes had been attacked more or less by the sulphur.

The boiler efficiency may often be greatly increased by the method of firing. The fireman has a great deal to do with the coal bill, especially as to keeping conditions uniform in the furnace. The mechanical stoker has done this in many cases to a great extent, but the man with the shovel can approach it, oftentimes, a great deal more closely than he does, especially with a high volatile coal. As quick as the coal is thrown on the red-hot bed of fuel, gases immediately begin to be given off, and in a gas coal at the end of five minutes there would be 33 per cent. of the heat of that coal given off, whether there is any air present or not. This determination was made by tests showing the loss in caloric value of coal after it had been on a bed of fuel for different lengths of time. With semi-bituminous coals this is much more uniform, and the gas is given off slower. There is not so much of it; the carbon remains until the air comes in contact with it. So that the fireman with the one-shovel method can save several per cent. over the man who piles fuel in regardless of anything else except his own desire to hurry up and get through with it and sit down as long as he can. The air supply should at all times be proportioned to the requirements of the coal. This is very important and the best way to approximate this result is by the use of the damper regulator. The losses which a fireman is accountable for are either unburned gases or excess air. With a thin fire or a fire with holes and too much draft, the amount of air passing through the fire is very great; sometimes causing a loss of 20 to 30 per cent.

The gas analysis in the boiler room is of much importance and the CO_2 machines that are now on the market are undoubtedly well worth their cost, if they were only perfected beyond the point of being an instrument. They are oftentimes found to be so delicate that the least thing will put them out of operation, and in some of the larger plants it has been found necessary to have a man detailed to look after those instruments alone. Otherwise they will give erroneous results, and as quick as the fireman has found that they can err he loses his confidence in them.

Another very important item is the question of cleanliness of the heating surface. The tubes are not blown sufficiently often in some plants; the scale is not kept out of the inside. An accumulation of this will cause a high flue temperature and considerable loss. There was a 225 h.-p. boiler running at about 60 per cent. of its rated capacity; the flue temperature was 624°. This was very high for that type of boiler running at that rate. The tubes were scraped at noon. During the afternoon the load, which was very uniform throughout the 24 hours, was practically unchanged and the temperature during the afternoon was 370°. This would mean several per cent. if there had been a very large air excess, but the gas analyzed about 14 per cent. CO_2, so that the air excess was very low, but even in this case of extremely low air excess the saving in efficiency of that boiler after the tubes were scraped was over 6 per cent.

LARGE MARINE STEAM TURBINES of the Curtis type are under construction for the Japanese Government by the Fore River Ship Building Co. at Quincy, Mass. Two 120-in. units are for a 23-knot cruiser and two 144-in. units for a battleship.

Electric Traction Experiments on the Lehigh Canal.

The Lehigh Canal is generally considered to be the most useful of the canals built to connect the anthracite coal fields with the Atlantic seaboard. It has felt railway competition very keenly, however, and in the fall of last year President Lathrop, of the L. Coal & Navigation Co., retained Messrs. L. B. Stillwell and H. St. C. Putnam to investigate certain phases of electric haulage, which was being considered as a means of improving the service and reducing its cost. A paper on the tests was presented to the American Institute of Electrical Engineers on March 13 by Messrs. Stillwell and Putnam, from which the following notes have been taken.

One section of the canal, 10,095 ft. long, is equipped with two locomotives, each weighing under test conditions 16,000 lb. Each is equipped with two direct-current motors of 28-h.-p., operating on 500-volt trolley circuits. The locomotive wheels are 28 in. in diameter and gear-ratio of 69/15. The wheel-base is 44 in. The locomotives operate on a track of 42-in. gauge, ballasted with broken stone or gravel. Forty-pound rails were used. The track is comparatively rough. On this section, two levels of the canal, aggregating 5,600 ft. in length, are in the open river, exposed to the river currents. The voltage of the trolley circuits was varied to obtain various towage speeds.

Another section of the canal 10,555 ft. long was equipped with three traction machines. Two of these tractors were manufactured in this country. The electric equipment of each comprised one direct-current 40-h.p. motor. The gear-ratio was 5.78 to 1; diameter of wheels 12 in., and length of wheel-base 42 in. The tractor runs on an I-beam and has lower wheels which are pressed upward against the lower flange of the beam with a force 4.7 times the drag on the tow line. The adhesion of the machine, therefore, is a function not only of its weight but also of the pull which it exerts. Each tractor weighs, with instruments and crew, 7,350 lb. Tractor 3 was manufactured in Paris, and equipped with one 25-h.p. mining motor. Its wheels are 11.25 in. in diameter, gear-ratio is 3.4 to 1, and wheel-base 42 in. The general design is the same as that of the American machines. Its frame had not been designed to receive a motor of the dimensions of that with which it was equipped, and it was necessary, therefore, to use 500 lb. counterweight to secure equilibrium of the machine. The weight of the tractor, including counterweight, test apparatus and crew was 6,493 lb.

The tractors were operated on a 10-in. 75-lb. I-beam supported 4 ft. above ground by steel posts placed at intervals of 18 ft.

A fourth tractor, built in Paris, was also subjected to preliminary tests, which showed it was of insufficient capacity for the service required. This machine, without crew and instruments, weighed 3,465 lb. It was equipped with one direct-current 500-volt motor of 15 h.p. The diameter of wheels was 12.75 in. and the wheel base 24 in.

Marks were made at distances of 52.8 ft. along the track. As each point was passed by the machine undergoing test, a push-button record was made by a signal pen in a graphic recording wattmeter and at the same instant the voltmeter and dynamometer were read by the test crew. In addition, during one complete run, the angle formed by the tow-rope and the center line of the track was determined at each distance point by measuring the distance from the center of the track to a fixed length of tow-line. All test results were corrected for this angle, and the tow-line pulls stated were the effective pulls in the direction of motion. In the tests the tow-line was approximately 200 ft. long.

Four canal boats were loaded and used in all comparative tests made. They were 87½ ft. long, 10 ft. 5 in. wide and drew about 5 ft. 2 in. They weighed about 23½ tons empty and 137 tons loaded. In addition to tests with these four boats, the regular canal traffic was handled by the test machines on their respective sections during the months of October and November and a part of September. Complete tests were made from time to time as opportunity offered, until it was thought that sufficient data had been collected.

The velocity of the current of water flowing in each section of the canal was determined at the time the tests were made, but to obtain an average value for towing resistance, including the effect of this current and also of track grade, all tests were made in both directions over each section of the canal. The average results are used in the calculations.

Effective tow-rope pulls required.—The average effective tow-rope pulls as determined by dynamometer tests and corrected for the rope-angle for four-, two-, and one-boat tests, both light and loaded, are given in the accompanying table:

AVERAGE EFFECTIVE TOW-ROPE PULLS.

Boats.	Weight, tons.	Average speed, mi. per hr.	Effective pull, lb.	Constant (CV^2T)
Four boats loaded	548	2.98	2200	0.452
Two boats loaded	274	3.62	1500	0.418
One boat loaded	137	4.00	1000	0.456
Four boats empty	95	4.00	1010	0.664
Two boats empty	47.5	4.20	560	0.668
One boat empty	23.8	5.00	400	0.673

In the majority of the two-boat tests, the boats were equipped with the so-called Erie steering gear. With this gear the second boat is used as a rudder for the first boat, to which it is tightly lashed. The effect, so far as resistance of the water is concerned, is a reduction of approximately 8 per cent. in the pull required; in addition to which saving the boats are kept in better alignment and are under better control. In the majority of the four-boat-tests, the first two boats were equipped with the Erie steering gear, but this beneficial reduction of pull was apparently lost, owing probably to the effect of the drag of the last two boats, which tended to alter the position of the first two with reference to the line of motion. For boats used on the Lehigh and Delaware canals, the effective tow-rope pull in pounds, required for any number of loaded boats, is expressed approximately by the formula 0.45 $V^2\ T$, and for empty boats by 0.67 $V^2\ T$, where V is the speed in miles per hour and T the total tons (2,000 lb.). No tests were made of partly loaded boats, but for these the following formula must be approximately correct: Effective pull required equals

$$\left(0.67 - \frac{0.22 \times \text{net load per boat}}{113}\right) V^2\ T.$$

It was impracticable with the facilities at hand to secure reliable data as to the effect of the ratio of boat-section to canal-section. The immersed cross-section of a loaded boat is 54 sq. ft., while the average cross-section of a canal, on those sections upon which most of the tests were made, is 440 sq. ft., the ratio of section being practically 1 to 8. The current in the open-river section is so varied that reliable results expressing difference in pull required in the comparatively narrow sections and in these wider sections could not be obtained.

Towing Machines Tested.—In most of the tests mining locomotive 15 and tractors 1 and 3 were used. Comparison was made at speeds and effective pulls as nearly identical as was found practicable. As to meet these conditions the various machines tested required different operating energy, and as change in the energy affected the motor efficiency, the electric losses in the motors in all cases have been deducted from the kilowatt input in determining the mechanical efficiency of the machines. The mechanical loss of the motors and gears in each case is charged against the respective machines. The tow-line pull in all cases has been corrected to the effective pull in pounds in the direction of motion.

EFFICIENCY OF TOWING MACHINES.

	Effective Pull = 1,000 lb.	Effective Pull = 2,000 lb.	Effective Pull = 3,000 lb.
Locomotive	80%	83.5%	84%
Tractor 1	68%	73.3%	74.8%
Tractor 2	73%	77.2%	77.5%

In running without load the machines preserve approximately the same relationship as they do when operating under load conditions, though the relative magnitudes of the values are changed. When developing large draw-bar pulls, the mechanical losses in tractor 3 are 50 per cent. in excess of those of the locomotive. Mechanical losses in tractor 1 exceed those of the locomotive by from 70 to 80 per cent. Under light running conditions these excess losses are reduced to about 7 per cent. in the case of tractor 3, though the excess remains approximately 70 per cent. for tractor 1.

The running light losses are, in themselves, relatively unimportant, as the amount of power required is small and the amount of idle running relatively very small; but, as showing errors in design and workmanship, which are corroborated by the results of the heavy load tests, they are considered important by Messrs. Stillwell and Putnam.

Speed limitations and length of tow.—In hauling canal boats by mules, the speeds attained vary from 1¼ to 2 miles an hour. When the current assists, the speed exceeds these amounts; when the tow is against the current, the speed sometimes drops very low. Dynamometer tests showed that in starting a tow, a team of good mules could exert momentary pull approximating 800 lb. This is maintained but momentarily. The average speed at which a team of mules draws a one-boat tow approximates 1¾ miles an hour and does not exceed 2 miles an hour in still water. The pull required at 2 miles an hour, as determined by the tests in which the locomotive and tractors were used, is 250 lb.; at 1¾ miles an hour it is 190 lb., and at 1.5 miles an hour it approximates 140 lb.

Tests were made to determine the practicable limits of speed when towing is done with towing machines. These limits depend upon the following: (*a*) Ability to steer the boats, (*b*) wash of canal banks, (*c*) time required for locking, (*d*) tonnage capacity and length of tow. The selection of a best speed depends also upon the number of boats which must pass through the canal in a given time to handle its business.

Ability to steer boats.—Single boats, both loaded and empty, were tested at speeds slightly exceeding 5 miles an hour and no difficulty was experienced in steering them.

Two-boat tows loaded were operated at speeds up to 4½ miles an hour. With the Erie steering gear the boats handled well at this speed, but care had to be exercised by the helmsman to keep his course true. Two-boat tows (light) were operated successfully at a speed of 5.3 miles an hour.

Four-boat tows (loaded), the first two boats being equipped with the Erie steering gear, were operated at a speed of 3½ miles an hour. At this speed, however, it was necessary for the helmsman to exercise great care to prevent the boats yawing. Four-boat tows, empty, were operated at speeds up to 5 miles an hour, but great difficulty was experienced in steering; the drag of the rear boat's pulling the head boats against the bank in spite of anything the helmsman could do. This was especially noticeable in going around curves convex with reference to the bank upon which the tow-path was located. It was found quite impossible to start four-boat tows on such a curve.

Wash of canal banks.—At the higher speeds covered by the tests a tendency to cause wash of the canal banks was noted. The tests were not of sufficient duration to justify an attempt at estimating the relation of wash and speed.

At a given speed the wash is greatest in narrow sections of the canal. To a certain extent in these sections the speed is automatically regulated; the resistance to the passage of the boat being increased and this resistance immediately reacting upon the series motor used in the tests.

The speed of towing should be under the control of the operator, and to obtain best results the motor used should be capable of operating at any desired speed within the predetermined maximum limits. With equipment of this character, the speed can be regulated on these sections where the wash might otherwise be injurious.

Time required for locking.—Tests were made to determine the time required in locking one, two and four boats and to see if the time could be reduced in any way. The actual time determined by tests, and Messrs. Stillwell and Putnam's estimate for average conditions, are given in the table:

TIME REQUIRED FOR LOCKING AT TWO-BOAT LOCKS.

	Observed.	Estimated.
Time locking four boats..........	29.5 min.	35 min.
Time locking two boats..........	12.0 min.	15 min.
Time locking one boat..........	8.0 min.	10 min.

In four-boat locks, with the first two boats and the last two boats equipped with Erie steering-gear, it would not be necessary to disconnect the steering-gear and the time of locking would not greatly exceed that for two boats. An estimate of 20 minutes, Messrs. Stillwell and Putnam consider conservative. No actual tests of the single-boat locks on the Delaware canal were made using canal boats, but during a trip of inspection the time of all lockings of the launch used were taken, and from these observations the time of locking for canal boats was estimated. The accompanying table gives the estimated average time for locking with tows of different lengths and with locks of different size as used in our calculations:

ESTIMATED AVERAGE TIME FOR LOCKING.

	1 boat lock.	2 boat lock.	4 boat lock.
Time locking four boats	45 min.	35 min.	20 min.
Time locking two boats	21 min.	15 min.	12 min.
Time locking one boat	8 min.	10 min.	11 min.

The accompanying table gives the speeds recommended for tows varying from one to four boats, loaded and empty, assuming, (*a*), that direct-current series motors are employed, and, (*b*), that single-phase alternating-current motors of the compensated type be used:

MAXIMUM SPEED BETWEEN LOCKS.

	Direct current.	Alternating current.
Four boats loaded....	3.00	2.88
Four boats empty....	4.00	4.20
Two boats loaded....	3.45	3.45
Two boats empty....	4.60	5.00
One boat loaded.....	4.00	4.20
One boat empty.....	5.30	6.00

The authors' conclusions in respect to speeds are based upon the observed facts as regards ability to steer boats, the wash of canal banks, the relative time required in locking, and between locks and the tonnage capacity of the canal as affected by the length of tow.

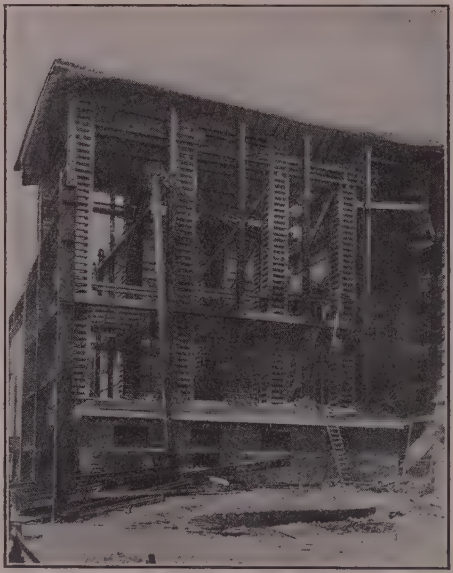
Tonnage capacity and length of tow.—As the length of tow limits the practicable running speed and determines the time consumed in locking, the length of the tow directly affects the tonnage capacity of the canal. The maximum running speeds described above give average running speeds which were determined from speed-time curves.

In order to handle a definite amount of freight, it is evident that a definite number of boats will have to pass through the canal, whether they are operated in four, two, or one boat tows. The number of boats required for this service, however, will be proportional to the time required for a round trip. With a fixed amount of freight to be handled, therefore, it is evident that fewer boats will be required with one-boat tows on account of the higher average speed. The number of towing machines required for the service is proportional to the round trips required and the time for the round trip.

The ultimate capacity of the canal is limited by the time required in locking. Since boats are moving in both directions, the interval between tows is double the maximum time required in passing through that lock on the canal which requires the maximum time for the towing unit employed.

Shoring the Roof of the Carnegie Library Building, Pittsburg.

A 60 x 60-ft. wing of the Carnegie Library Building, or as it is better known the Carnegie Institute, Pittsburg, is about 50 ft. high from first floor to roof and was used as a book stack with several floors about 8 ft. apart. The stone walls carried the floors and roof trusses and the roof and ceiling were composed of book tiles carried by T-bars supported on I-beam purlins and on the horizontal bottom chords of the trusses respectively. In accordance with the alterations involved by the recent enlargement of the building it was necessary to entirely remove the wall and construct a new steel framework with new floors at different levels from the old ones and carried by steel girders on wall columns. The roof and ceiling were not materially altered, and as they remained in substantially the same position it was decided to support them independently while the old floors were replaced by new ones.



Shoring a Library Roof.

The old substructure was not removed below the first floor, and the latter being properly shored up from the solid basement floor served as a stable foundation on which the falsework about 50 ft. high was erected to carry an estimated load of about 100 tons.

The floors and roof in the adjacent part of the main building were supported on vertical timbers shown at the right of the picture, but as these could not be used full-length in the wing it was estimated to be as cheap and much more convenient to substitute crib work for them; and as the latter has the advantage of a wider base and greater stability, is easily and safely handled, and is always quickly available from the large quantities kept in stock, it was adopted for this purpose. Eight cribs about 4 ft. square were built in the planes of the trusses about 1 ft. clear of the inner face of the wall and located so as to clear the new columns, beams and girders. The cribs were built of short lengths of 6 x 6-in. timber except that near the middle and just below the the faces of two adjacent piers were built in to upper end long pieces of timber reaching across bond them together and provide lateral bracing. Planks laid across the upper courses of these timbers served as working platforms, and jack screws were set on the tops of the piers engaging transverse timbers under the bottom flanges of the roof trusses. When the new columns were erected the jack screws were operated to raise or lower the roof trusses to correspond and finally were slacked off to seat the trusses on the columns. By this method the building was practically constructed under the old roof without material injury to the latter and considerable economy of time and money was effected. Alden & Harlow were the architects of the work and the John Eichleay, Jr., Co. was the contractor for the shoring here described.

Bridge Inspection on Massachusetts Railroads.

In the annual report of Prof. Geo. T. Swain, as engineer of the Massachusetts Railroad Commission, he gives the following notes concerning methods of bridge inspection followed on the various railroads of the State:

On the Boston & Albany R.R. the line is divided into three divisions and each division is assigned to an inspector who carefully inspects each bridge once a month, the inspection of the structures upon each division requiring about this length of time. After completing the inspection he makes a report to the division roadmaster and starts again for another month's trip. From the roadmaster the report goes to the bridge engineer. The inspector is expected to examine every accsssible part of each bridge, and his report is submitted on a prescribed blank form in which the condition of each part of each structure is to be stated, together with the number of loose rivets found and any other facts which are disclosed.

In case the monthly inspection discloses any fact which seems to the inspector to require immediate attention, or which seems to him doubtful, the bridge engineer is notified immediately, visits the structure, decides what, if anything, should be done, and arranges to have it done. The biennial report to the Commission is made by the bridge engineer on the basis of his close knowledge of the actual condition of each structure.

On the New York, New Haven & Hartford R.R. the bridges are inspected by the division bridge supervisors or their assistants, who report to the division engineer. There is no uniformity in respect to the frequency of inspection. Old structures are usually inspected once a month, while if there are any details in a structure which give any indication of deterioration or progressive changes these are watched at even more frequent intervals. New structures are supposed to be completely inspected once in three months. Each inspection is required to be thorough, every accessible part being examined. Blank forms are not employed, but any facts which are discovered are noted and reported to the division engineer. In case the bridge supervisor is doubtful about a structure he notifies the bridge engineer or his assistant, who makes a careful examination. When the biennial reports are to be made all the bridges are personally examined either by the division engineer or the engineer of bridges.

On the Central Vermont R.R. inspecting is done by the general foreman, who reports to the superintendent of structures. There is no set time for inspection, but the general foreman goes over the bridges during the spring and makes his report thereafter. The inspection is complete and is made for the purpose of providing for the work to be done during the following season. In addition to the yearly inspection by the general foreman, the bridge foreman on each division makes frequent inspections of the bridges on his division and calls any important matter immediately to the attention of the superintendent of structures.

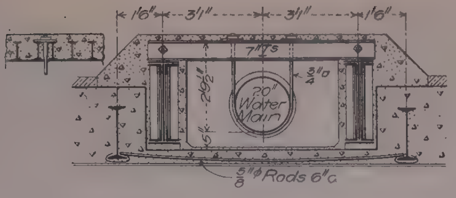
THE PANAMA CANAL EXCAVATION during February was 2,945,880 yd., of which 1,248,265 yd. were taken out on the Culebra division

The United States Capitol Subways.

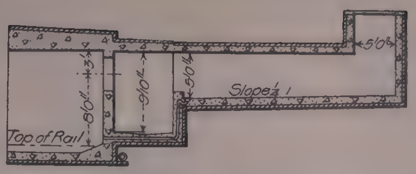
By W. J. Knight.

There have recently been completed two reinforced concrete subways connecting the United States Capitol with the Senate and House office buildings, and though offering no special features of design or construction, may prove of interest to the readers of this journal. The Senate and House office buildings now nearing completion, are located several hundred feet from the North and South wings respectively of the Capitol and in order to avoid the usual confusion and inconvenience of surface traffic, it was deemed necessary to construct two subways to facilitate passage to and from these buildings.

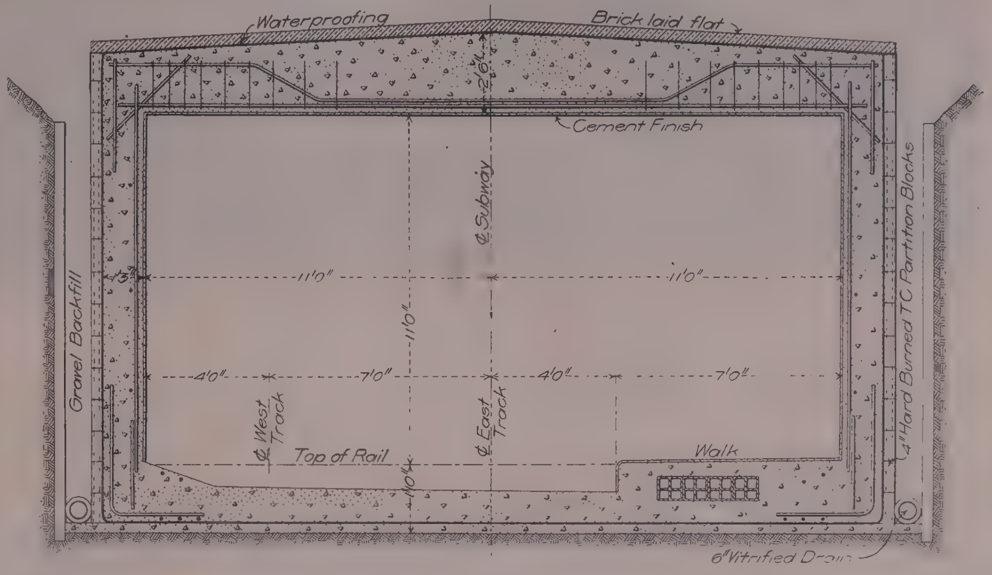
The subways are of reinforced concrete throughout, being 22 ft. in clear width and about 1287 ft. in length, including both Senate and House connections. The interior of each subway is provided with one 7-ft. sidewalk and a clear space of 15 ft., measured from curb of sidewalk to further wall, which is to be occupied by a double narrow gauge track. From the top of the rail to the bottom of the roof there is clearance of 11 ft. Both the Senate and House subways are built on a grade increasing in elevation towards the Capitol, the former having a maximum of 3.84 per cent and the latter a 3.37 per cent grade. At the Capitol end of each subway there is located a station and a fan chamber, the latter being located in each case at the beginning of the curve entering the Capitol. The cross-sections of both subways are uniform throughout in so far as the thickness of concrete in the walls, roof and floor slab are concerned, and differ only in the reinforcement of the roof at the places indicated on the two general plans.



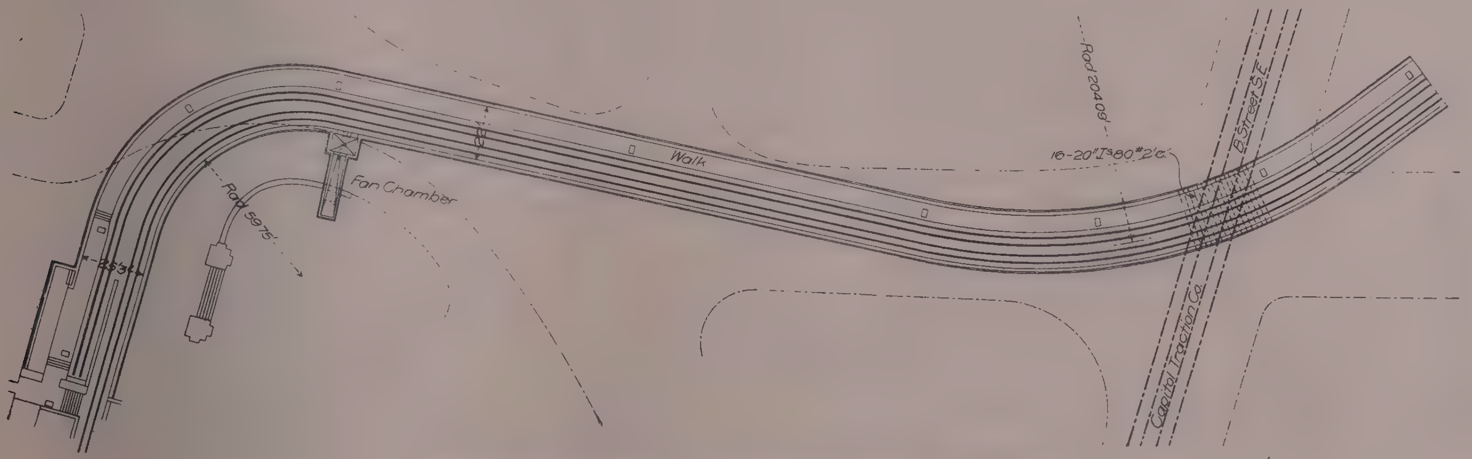
Water-Main Support over Roof.



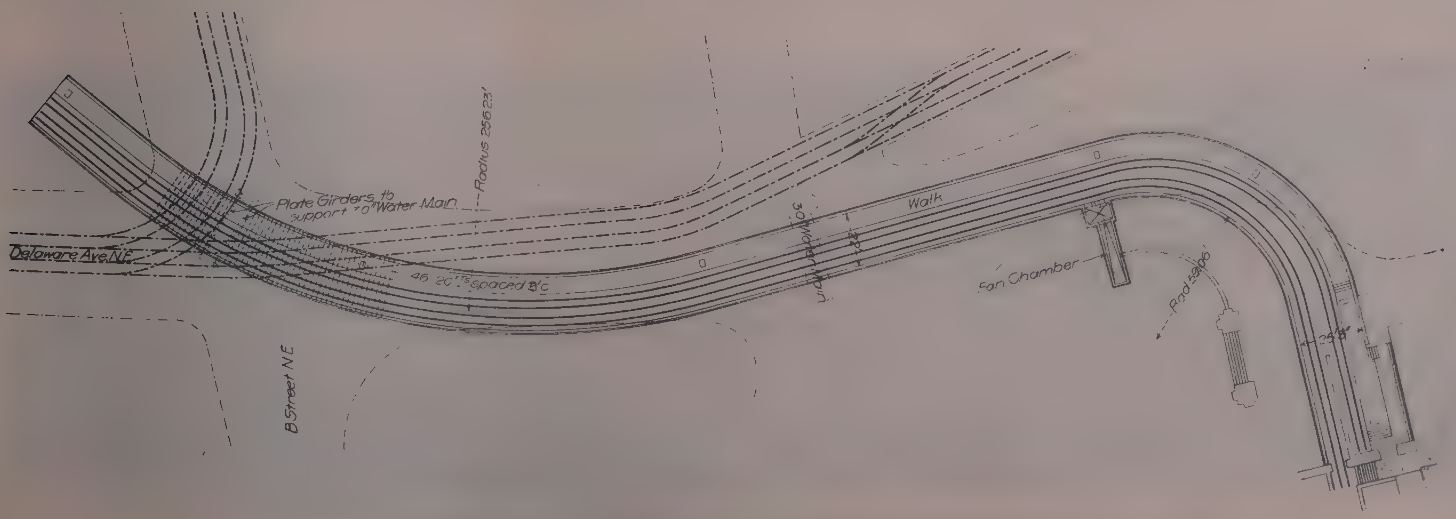
Arrangement of Fan Chamber.



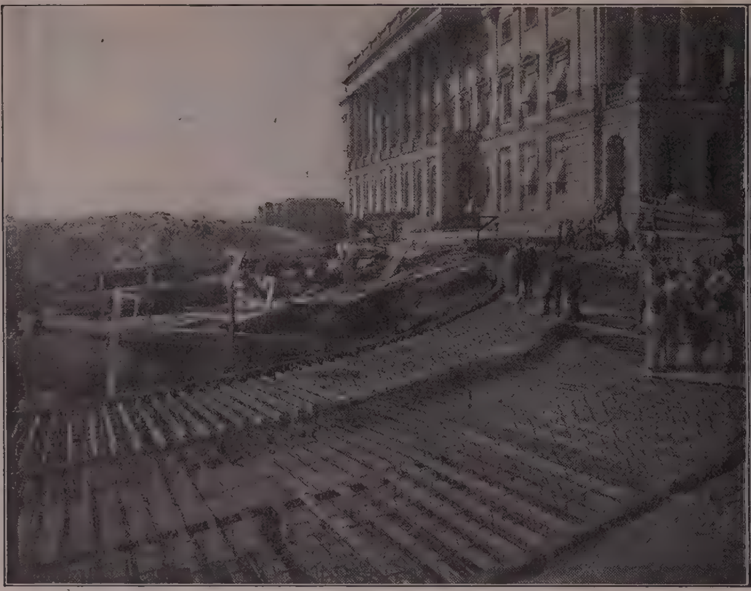
General Cross-Section of the U. S. Capitol Subway.



General Plan of Subway U. S. Capitol to House Office Building.



General Plan of Subway U. S. Capitol to Senate Office Building.



Construction of Subway Roof.

Bracing the Subway Trench.

The roof slab is 2 ft. 6 in. thick at the center of the subway and gradually decreases in thickness towards the sidewalks, making a slope of about ⅝ in. in 12 in. on the top, to afford ready drainage. The side walls are 1 ft. 3 in. thick. The stations as well as the side walls of the subways are to be finished from floor to ceiling with either cement, tile or brick; which kind of finishing surface to be used has not yet been decided.

The stations, one at the capitol end of each subway, are practically alike in every detail. Before entering the station from the subway the tracks divide, one terminating in the station and the other continuing into the basement corridor of the Capitol, the west wall of the station serving as a dividing wall between the two tracks. The roofs over the station and over the west track are of flat arch construction, consisting in the former case of concrete arches resting on 15-in. 80-lb. I-beams spaced 4 ft. on centers, with tie rods connecting upper flanges of beams, and in the latter case of 7-in. I-beams spaced approximately 4 ft. center to center with tie-rod connections.

The roof slab shown in the typical section was designed for a total dead and live load of 500 lb. per square foot, and the sections of roof supporting car tracks for 800 lb. per square foot, including dead and live loads.

Originally expansion joints were considered advisable at specified intervals but after due consideration as to the conditions favorable to the elimination of expansion joints, it was decided to build the structure monolithic. The design of the cars to be operated on the subway tracks is still a matter for future consideration. However, electricity is to be the motive power and will probably be generated by storage batteries underneath the cars, in which case the current for charging the batteries will be obtained from the new power plant about to be built.

The reinforcement of the walls consists of both vertical and horizontal bars near the inner face, plain round rods of mild steel being used in all cases. The vertical rods are 1 in. in diameter and spaced throughout 6 in. on centers. Those laid horizontally consist of three ½-in. diameter rods spaced 36 in. apart and 3¼ in. from the inner face of the wall. At the upper end of the wall, 3 in. from the outer face and projecting vertically into the roof slab, are ¾-in. rods 3 ft. long spaced 15 in. apart. In the lower end of the wall there are ¾-in. rods 12 in. apart and 7 ft. long, bent as shown in the typical section, with 3-ft. ends projecting horizontally into the floor slab, and 4-ft. ends projecting up into the wall. Adjacent to these and lying in the rear of every fourth vertical 1-in. rod are ¾-in. anchor rods 24 in. apart and 3 ft. long. Five ¾-in. rods near the base of the wall are placed in the floor and run continuous throughout the subways.

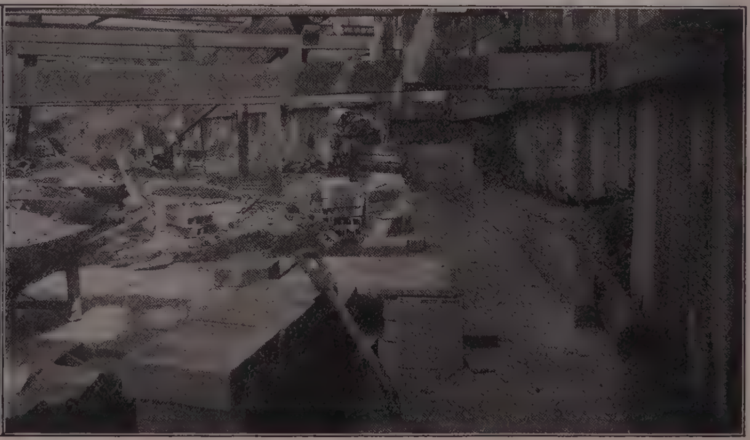
The reinforcement in the roof consists of two 1⅛-in. rods every 12 in. placed as units, one rod above the other. The upper one is bent at the quarter points and extends into the upper portion of the slab to provide for shearing and diagonal tension.

The stirrups are made of ¼ x ¾ in. flats bent in a rectangular shape with 7-in. flange projections. The stirrups are wired securely with No. 9 galvanized wire to the two 1⅛-in. rods and spaced 6 in. apart at the point of greatest shear and gradually increasing to 12 in. at the quarter point. Where the roof forms an integral part of the wall ¾-in. rods 24 in. apart and 4 ft. long are laid diagonally.

Where the Senate subway passes under the intersection of Delaware Ave. and B St., there are four tracks of the Washington Railway & Electric Co. To provide for this extra load the 1⅛-in. rods of the roof are replaced by 46 20-in. 80-lb I-beams spaced radially 2 ft. on centers at the center line of the subway. Near the House office building at the intersection of B St. and New Jersey Ave. sixteen 20-in. 80-lb. I-beams are used in the roof slab to support two car tracks of the Capitol Traction Co. and are spaced as described above.

The system employed in waterproofing the subways consisted essentially of four layers of tarred felt breaking joints in all directions and cemented together with coal tar. After a 4-in. layer of concrete was placed in the bottom of the excavation to obtain the level surface required, the waterproofing for the bottom was applied. On this the concrete floor proper was placed. For the waterproofing of the walls, there was first built a 4-in. hollow terra-cotta wall about 1 ft. clear of the sheet piling, the latter being held in position by a system of shoring passing through the former at intervals as great as the weight of the earth against the sheeting would permit, so as to have a surface broken as little as possible. The waterproofing for the walls was then carried up in sections against the inner face of the terra-cotta wall. The reinforced concrete walls were then

Terra-Cotta Wall of Subway.



Drain behind Terra-Cotta Wall.

built. After the roof slab was in place, and as the work was so readily accessible, little difficulty was experienced in applying the waterproofing for this portion of the subway.

In order to afford the best protection to the waterproofing of the roof slab against the injurious effects of backfilling, a course of common brick was laid flat over the entire area with just enough mortar to hold them in place.

The hollow terra-cotta walls enabled the waterproofing of sides to be done with facility from the inside, and besides providing an excellent surface for the application of the felt, the blocks, having their voids vertical, formed a series of vertical drains for water percolating through the ground, which would be intercepted by the subway construction. At the foot of this terra-cotta wall, all intercepted water is carried off to a sewer by a 6-in. vitrified drain with open joints, the drain running the entire length of the subway.

The space between the hollow tile wall and the sheet piling, necessary for the introduction of the vitrified drain, was filled with clean gravel.

Over the Senate subway it was necessary to carry two water mains, 20 and 30 in. in diameter, running at right angles to the subway. To accomplish this for the 20-in. water main, two brick piers, clearing the walls of the subway, were built to support two parallel girders 6 ft. 2 in. apart, which in turn supported transverse 7-in. I-beams used in pairs spaced 3 ft. on centers, from which were hung ¾-in. wrought iron hangers supporting directly the water main. Between the pairs of 7-in. I-beams, forming the water main supports are two 7-in. I-beams, except where the water main is beneath the car tracks, in which case three intermediate beams are used.

The girders measure 2 ft. 6½ in. back to back of angles and consist of a 30 x ½ in. web plate, 12 x ⅜-in. cover plates, 5 x 3 ½ x ½-in. flange angles and 4 x 3½ x ⅜-in. stiffeners, spaced 2 ft. 6 in. apart.

The girders and I-beams are encased in concrete, enough space around the water main being left to afford access should any repairs be found necessary. The flooring of this interior space forms also the roof of the subway and is reinforced with ⅝-in. rods 6 in. apart. The flooring has a slope of ⅛ in. in 12 in. to permit of drainage in case of possible leakage from the water main, the water being carried by a 4-in. drain into the 6-in. vitrified drain embedded in the concrete footing at the bottom of the 4-in. hollow brick wall. All water mains were carried above subways and all sewers underneath.

For the entire subway, the concrete used consisted of one part of Alpha cement, two parts of sand and four of broken stone. Blue gneiss rock quarried on the banks of the Potomac River a few miles from the site of the work was used throughout. The sand was of exceptionally good quality, containing only about 1 per cent loam. The construction of forms for the walls and roof presented no problems of unusual difficulty, although the timbering used in bracing the sheeting caused from time to time considerable trouble in obtaining sufficient clearance at different stages of waterproofing and concreting. Unusual care was exercised in maintaining the proper spacing of all rods. The sheeting was driven by hand and allowed to remain permanently. All excavation, consisting principally of clay and gravel, was done with pick and shovel and raised by derricks into wagons and either dumped temporarily for backfilling, or carried to court yards of Senate and House buildings for filling purposes. The concrete was mixed wet by Smith mixers stationed near the edge of the excavation, and carried in wheelbarrows over the forms and dumped as required. Four temporary wooden bridges were built to accommodate traffic during construction. The work was begun July 5, 1907, and with night and day shifts was completed Dec. 24, 1907.

The quantities per linear foot of construction are about 475 lb. of steel, 5.3 cu. yd. of concrete and 17.7 cu. yd. excavation. The subways were originally designed by Mr. F. L. Averill, then in the office of the Superintendent U. S. Capitol Building and Grounds, and afterwards re-designed on account of changes in the alignment and grades, by Mr. Owen Brainard, of the firm of Carrere & Hastings, architects, New York. The entire work was executed under the personal supervision of Mr. Elliott Woods, Superintendent of U. S. Capitol Building and Grounds. The contractors were R. S. Blome Co., of Chicago and Washington. The writer is indebted to Mr. Oscar Wenderoth, chief draftsman, for the information received.

Present-Day Road Requirements in Town and Country.

A paper read before the Royal Sanitary Institute by Mr. A. Brown, City Engineer, Nottingham.

The subject, as you will see from your programme, is "Present-Day Road Requirements in Town and Country." What are those requirements? They may, I think, be classed under six different heads:

(1) The surface must give good foothold for horses.

(2) It must be as noiseless as possible.

(3) It must be free from dust in summer, and free from mud in winter.

(4) It must be of such a surface as will prevent side-slip with either motor-cars or cycles.

(5) The surface must stand the traffic of the district.

(6) Lastly, the road must be cheap as regards first cost or maintenance, or both.

The order of importance of those requirements is somewhat difficult to give. For instance, the man who drives a horse thinks good foothold is of the greatest importance, and many people who do not drive horses will agree with him. Residents who live abutting on our main highways consider absence of noise, and freedom from dust and mud, as being of the greatest importance. Cyclists and motorists take no interest in a road being noiseless, as they ride on rubber tires, but they do demand roads free from dust and mud, and consider a surface which does not encourage side-slip as being to them a *sine quâ non*.

No. 5, that the road must stand the traffic of the district without undue expenditure in repairs, is one which the road engineer makes it his business to try and carry out. The last requirement, No. 6, is one on which we can obtain a unanimous vote: the road must be cheap.

The "man in the street," whose opinion we are often told it is quite safe to follow, would, I have no doubt, tell you that it is easy to make a road to fulfil all these requirements. Well, the man who succeeds in that would not stop there; his next achievement would be to discover perpetual motion or to extract gold in quantities from sea water.

I believe you will agree with me that the problem of making and maintaining the main streets and roads in our cities and counties is not an easy one, and it is rendered every day more difficult in consequence of the disinclination of the powers that be to spend more money on this object; money can be found, and has to be found, in any quantity for education, and there is no department connected with municipal and county work which is not starved and stinted in order to find further funds for this one department.

I propose—

(1) To describe shortly the various kinds of paving to be found in the main streets of our cities and urban districts, with the cost of each, and how far each type fulfils any of the six requirements.

(2) To refer to the dust nuisance generally, and describe some of the palliatives which have been used to combat that nuisance.

(3) To suggest what in my opinion is to be the construction of the urban and country highway in the future.

(4) What the improvement of roads will cost; and how the money will be found to pay for these improvements.

(1) As regards the various kinds of road paving, etc., for main street and urban roads we have (*a*) granite sett paving, which is a favorite type with every road engineer on account of its durability. The kind of granite depends on the position, geographically, of the town; Nottingham, in consequence of its inland position, cannot obtain cheaply either Welsh, Scotch or Guernsey granite, and is dependent on a supply from the Leicestershire quarries. Norway has during the past eight years been a strong competitor to the Leicestershire quarry owners; the granite from the latter district is mainly hard and somewhat close grained, wears well, but naturally wears somewhat smooth and slippery; Norway granite is more open grained and gives fairly good foothold, but it is therefore softer than Leicestershire granite. The finest granite for sett paving is Aberdeen granite; it is hard, but it gives as good foothold as granite from Norway.

The setts are usually from 5 in. to 7 in. deep, and are laid on a concrete foundation 6 in. to 8 in. thick; the joints are run in with pitch and tar, and made quite impervious; the cost, including concrete foundation, is about 12s. 6d. per yard super. Its advantages are that there is no paving equal to this for carrying heavy traffic; it is free to a very great extent from dust and mud; there is no side-slip. Its disadvantages are that it is exceedingly noisy, and where traffic is heavy and on steep grades requires sanding daily. I have said it will stand heavy traffic, but there is one kind of traffic which can punish this pavement, and that is the traction engine weighing 18 tons, hauling three loaded trucks, each weighing 12 tons; the steel strips on the driving wheels of the traction engine snip off the edges of the setts and destroy the appearance of the paving and its durability, and by increasing the space between each sett makes the paving more noisy. All this could be avoided if traction-engine owners would use wheels filled in with rims of hard wood, but these are rather more expensive to maintain than the steel-rimmed wheels. I would stop this damage by putting a tax of £100 a year on steel-shod traction engines, and £20 a year on wooden-shod ones.

(*b*) Wood paving for busy thoroughfares is the most popular pavement; it is the pavement which every ratepayer desires to have in front of his own premises, and, curiously, it is the most expensive. The usual foundation of 6 in. or 8 in. thick of Portland cement concrete, with a finely screened surface to receive the blocks, is absolutely necessary. Almost every kind of wood has been tried, but during the past ten years Australian hardwood has been most largely used; it was greatly boomed by the Australian Government, and practically almost ousted creosoted red deal. There are two principal kinds of this hardwood, jarrah and karri; the wood is very hard and very heavy, its specific gravity being higher than water, but it is rather brittle; the edges break away and cause the joints to appear wide, although the blocks are closely paved. It is, although so close-grained and hard, a most extraordinary wood for expansion and contraction; its greatest drawback, however, is its slipperiness; to say that it requires sanding daily is putting the matter very mildly; some roads paved with hardwood in Nottingham, in certain conditions of weather, have been sanded five or six times daily. The blocks are dipped in pitch and tar, and paved quite close, and a space left at the kerbs filled in with soft clay to take up the expansion. The cost of jarrah paving is from 14s. to 16s. per square yard, depending upon the price of the timber, which fluctuates a good deal.

Those who have to maintain city roads believe that creosoted red deal will, and in fact it has, come into favor again. Its cost is less than hardwood; it costs less in sanding; and if the timber is good, sound stuff, and well creosoted, it will wear nearly as long as hardwood. The creosote preserves the life of the timber and is an antiseptic. No better instance of creosoted red deal paving could be given than the piece in front of the Nottingham Guildhall, which has been laid for twenty-two years, has not cost £5 in repairs, and is perfectly sound and not by any means at present worn out. No kind of uncreosoted wood could possibly show a result like this. The cost of creosoted wood paving is about 13s. per square yard.

Wood paving in dry weather gives the most perfect foothold of any road except ordinary dry macadam; and, on the other hand, in some conditions of weather it is a veritable skating rink when covered with a greasy slime peculiar to wood paving. When in this condition the sprinkling of sand only increases the trouble, and there is only one cure—a thorough washing, which, of course, has to take place at night. In very dry weather the dust from wood paving, although not large in amount, is particularly irritating; but this is caused by the pulverized horse droppings, which are more apparent on wood than any other kind of pavement. In dry weather the whole area of the wood paving must on no account be watered, unless you require a skating rink; the channels only should be watered with a cart, with the spreader arranged for this purpose. A wood-paved road fulfils requirement No. 1 as to foothold, and conditions No. 4 as regards side-slip only in dry weather; it fulfils condition No. 2 as regards freedom from noise; it fulfils condition No. 3 as regards dust and mud to a very great extent; as regards requirements Nos. 5 and 6 it is costly to maintain and is by no means cheap.

(*c*) The third type of road is the ordinary, what is termed dry, macadam road. This can only be used for urban roads. The absolute necessity of a good foundation for a macadam road is as great as in the two types already mentioned, but in the case of the macadam road it is usually of hard ballast, well rolled. The granite should be of the hardest and toughest description, and from 2 in. to 2¼ in. gauge for roads of importance. Macadam's rule was that the stone should not be larger than you could put in your mouth. I would not care, myself, to trust to the accuracy of this gauge, and prefer a metal one. The stones should be rolled and rolled until they are dovetailed together as in a mosaic pavement, and no binding material should be used until this has been effected. It should always be remembered that the less binding material you use in consolidating your road the less dust and mud you will have afterwards. Road scrapings should on no account be used for binding; they have been mud and will speedily return to their original condition. Fine granite only should be used for this purpose.

This road is the ideal one for foothold, for noiselessness, and for absence of side-slip. It will not carry heavy traffic, but it is cheap as regards first cost, a good road, including foundation, being made for from 2s. 6d. to 2s. 9d. per yard; but this class of road is the one which has given rise to all the troubles since the advent of the motor-car, as regards dust more particularly. Where the traffic is heavy, the process of taking off the mud and laying on the granite is almost continuous; where the ordinary traffic is light, and the motor traffic is heavy, the dust is a fearful nuisance.

(*d*) A paving which is just now in its early experimental stages in this country is a paving called Durax paving. This paving is laid on a foundation of hard ballast, or, as it is expected to take the place of the ordinary dry macadam roadway, it is suggested it should be laid on top of the existing macadam roads, when the levels will allow of this being done. The material is granite, about 3½ in. cube. The peculiarity of the method of paving is that the cubes are not laid in straight courses at right angles to the central axis of the road, but in courses having a segment with a cord about 5 ft. or 6 ft.; thus, if the road is 30 ft. wide there are five or six of these segments in the width of the road. The stones or cubes are laid as close together as possible, and are well rammed with a light rammer. The syndicate having charge of Durax paving suggest that the joints should be filled with sand, but I prefer to fill them in with pitch and tar, as in the case of ordinary sett paving. The noiselessness of this paving is certainly most extraordinary; it is quite inconsistent with one's ordinary ideas of a paved road. There is no doubt that the segmental shape of the courses conduces to the noiselessness in a marked degree. The road gives good foothold, is free from dust and mud, there is no side-slip, and it will stand fairly heavy urban traffic, but the cost is somewhat heavy (about 5s. 6d. per yard, exclusive of any foundation). Taking a road at 10 yds. wide, this price would equal £4,840 per mile run.

The syndicate believe that this road will supersede macadam roads in the country, and solve the dust and mud problem: there are nearly 27,500 miles of main roads in the country. What will our friends who still like to drive horses say to this length of paved roads? It was a very horsey man who understands horses, but not h's, who said: "It was not the pace that killed, but the 'ammer, 'ammer, 'ammer on the 'ard' igh road." This class of paving may, after trial, be found to be useful on busy urban roads where ordinary macadam is objected to on account of the dust, but its first cost will prevent its universal adoption on all main country roads.

(*e*) The last type of road is tar-macadam. There is nothing new in tar-macadam; it has been laid in this city for fifty years. The first piece of tarred paving in this country was laid on the London road about the year 1845.

The material most favored for use in making tar-macadam is ironstone slag, but I am certain that good results can be obtained by using certain kinds of granite. The advantage of using slag is that it is dry, and if the trucks in which it is delivered are sheeted down the material need only be slightly warmed before being treated.

I have often been asked for my prescription, which when given has sometimes been used by the patient with peculiar results. It was not the fault of the prescriber or of the patient, but the fault of the drugs used. There is nothing on earth which differs so greatly as the liquid called tar; good and poor qualities of tar are quite common, and chemical analysis, so far, does not always help you, and besides, the analysis of tar is rather an expensive matter, and unless you have every load analysed you are not certain, and this analysis would add 50 per cent to the cost of your material. Tar varies in quality at different gasworks, hence the futility of giving prescriptions of "so much tar to so much pitch," which in another town, buying tar from another gasworks, would cause failure. But the same thing applies to tar from any works; it differs at the same gasworks at different seasons of the year. The tar from one gasworks is quite different to the tar from another works in the same town. A different method in carbonizing the coal, using a lower grade of coal, and very often a change in the management, alters entirely the nature of the tar and renders it unsuitable for tar-macadam purposes.

I and others, including my friend Mr. Hooley, are trying to standardize, if possible, this material, and if tar-macadam is going to be used as extensively as some of us believe it will be, those who sell tar will have to sell it with a guarantee as to its constituents. I believe that nearly all the failures can be put down to the quality of the tar; those who have a free hand and can buy where they like can do better than those who must buy from one works only, and buy tar containing many things which are not required, and are harmful to the process of mixing and making tar-macadam.

There are a good many kinds of apparatus for mixing tar-macadam; but I do not, for obvious reasons, propose to describe these. The material when warmed and coated with tar is preferably stacked for a few weeks to mature, but this is not absolutely necessary. It is laid in two coats, the lower one about 3 in. to 4 in. thick of material 2 in. to 2¼ in. gauge, and the top coat 1¼ in. to 1½ in. thick of material 1 in. to 1¼. gauge. The whole is well rolled and covered with dry granite chippings.

There are limitations to the use of tar-macadam roads, and it is often laid down as a rule that this material should not be laid down on a gradient steeper than 1 in 18 or 1 in 20; in Nottingham there is a tar-macadam road laid on a gradient of 1 in 10, and heavily-laden drays pass down this road with safety; they do not come up; they could not, whatever the surface was laid with. In certain conditions of weather the foothold is not all that could be desired, but if the sanding staff is well organized this difficulty may be surmounted.

The cost of a new tar-macadam road, including foundations, etc., is about 3s. 6d. per yard super. This road fulfils condition No. 1 as to foothold, except in very frosty or greasy weather; it fulfils requirement No. 2 as to noiselessness, also requirement No. 3 regarding dust and mud, fulfils requirement No. 4 in dry, fine weather, but in greasy weather is apt to encourage side-slip; for urban roads it fulfils requirement No. 5, and it is fairly cheap and fulfils requirement No. 6.

We have not discovered any road which fulfils all the requirements laid down at the commencement of my remarks, and I do not think we ever shall.

(2) I now come to the dust nuisance and the various remedies which have been tried to alleviate the nuisance.

(*a*) The ordinary method of street watering: but how little effect this has on roads on very hot days in summer, when the sun's temperature rises to 140 deg. and the humidity falls to 45 as compared with 100 being complete saturation; watering in this condition of weather arouses in the staff a feeling of hopelessness and certainly an opinion whether the money so spent is not absolutely futile. I am speaking more particularly of urban macadam roads and not paved roads. How would it be possible to water the miles of country roads? It is difficult in cities where the water mains are everywhere and standposts frequent, but on the country roads there are thousands of miles where there are no water mains, and it increases the cost enormously when the water has to be carted a mile or more from the nearest pond or dyke; there is also the risk that the latter may be dried up during hot weather just when watering is most required.

Water can only be used with economy and with moderate success when standposts are placed at not more than ¼-mile intervals. Road watering on an urban road under these conditions costs from ¾d. to 1d. per yard super. per annum.

(*b*) Various oil preparations have been tried, with only moderate success, and have given place to materials of which calcium chloride is the principal ingredient. It has been known for years that street watering with sea water is more effective than watering with the town water supply; after the water has evaporated the particles of sea salt, which is really sodium chloride, remain; this is a deliquescent body, always taking up moisture from the air and remaining damp. Calcium chloride is a saline body, much like sodium chloride, but is more deliquescent, as, if some of the calcium chloride is exposed to the air for a short time, it attracts so much moisture from the air that it rapidly becomes a liquid. It is a by-product at the large chemical works, and is produced in enormous quantities, and it ought to be sold more cheaply than it is, the present price being about 30s. per ton, plus carriage. It is applied in the usual way by means of a water cart, the first dressing is a 10 per cent. solution, and the second a 5 per cent. solution. After the evaporation of the water, which is simply the medium by which the calcium chloride is applied to the road, the crystals of the calcium chloride are left on the surface of the road and attract moisture from the air and keep the surface of the road damp. Curiously, the greatest enemy of any oil process or calcium chloride mixture for laying dust is heavy rain; the latter washes the oil or calcium chloride from the surface of the road into the channels, and the process of treating the surface has to be repeated.

I have found calcium chloride very effective, and its great advantage over ordinary street watering is that it ensures a road with freedom from dust for twenty-four hours a day for seven days a week. A road requires treating about once a month, although this depends a good deal upon the amount of the traffic. The cost of treating roads with calcium chloride is about 25 per cent. less than ordinary street watering, but the comparison is hardly fair to calcium chloride for the reasons given above.

(*c*) Tar painting, or spraying, of roads has been strongly urged by its champions as being the only cure for dust. The Roads Improvement Association and the Automobile Club offered prizes last year for the best method of laying dust, and very extensive trials were made on roads near London. I saw some of these trials and have given the subject very careful attention. The roads upon which the trials were made were absolutely free from dust before the trials, and there was no dust afterwards, because there was no sunshine and plenty of rain. The trials proved nothing.

I would like to see tar painting or spraying tried in a hot, dry summer, when the system could be carefully tested. I am bound to say, however, that some surveyors speak very highly of it, and I understand that one surveyor in the south of England has given an order for the tar treating of 150 miles of road, so that there will be opportunities of watching this process if the weather is dry and favorable. One great drawback to tar-painting is that in winter, after frost and snow succeeded by continuous but not heavy rainfall, the road is coated with a black, slimy mud, which is very difficult to remove.

Tar painting is expensive. From figures I have obtained from those having experience, the cost is from 1d. to 2d. per yard per annum. This is the opinion of the county surveyor of Kent, who says: "If all the county roads are to be tar painted the cost would be £1,000,000 a year, and about 34,000,000 gallons of tar would be consumed, of a value of about £280,000." What a windfall for gasworks! And how long, in view of such a demand, would tar remain at its present price? Taking the cost at only 1d. per yard per annum, and the roads at an average of 10 yd. wide, would equal £73 per annum. I believe the average cost of the upkeep of county roads is only £60 per annum, and therefore the cost of maintenance of the county roads would be more than doubled if they had to be tar painted in order to lay the dust.

(3) I come now to the third point: what road will most effectually combat the dust and mud nuisance? I believe that the only road which will effectively do this is some kind of tar-macadam road, which could be made very cheaply if some of the enormous heaps of slag and granite which are now waste material could be utilized for the purpose, and if tar could be properly standardized and delivered to the user in a state fit for use without resorting to hours of continuous boiling. I have already said that a tar-macadam road would cost about 3s. 6d. per square yard, but this is for an entirely new road, and includes excavation, foundation, etc.; many roads have fairly good foundations, and these could have the coat of tar-macadam laid on the top, using the present macadam as a foundation.

(4) What would it cost, and who should pay for it? I believe that treating the country roads as suggested would cost £1,000 per mile; I think they could be done for that. I understand that there are about 27,500 miles of roads in England and Wales, there is, therefore, an expenditure of £27,500,000 to be faced; how is that money to be found? The easiest answer is that the State must find it. It is to me a most mysterious process of reasoning that State aid is a financial saving; everything must be paid for by the State —education, poor law, road maintenance, etc. Some people imagine that if you get a State grant you are relieved from making your share of the payment; they think there is some magic in the transferring a charge from the rates to the taxes; the money is found by the people in the end, and whether it is better to raise money by rates or taxes does not come within the scope of these remarks.

What has brought about the trouble regarding the upkeep and maintenance of urban and country roads? The answer is, the motor-car and other self-propelled vehicles. Road engineers are frequently told that they know nothing about the maintenance of roads, and that road surfaces are not brought up to everyday modern requirements; but road engineers might with equal truth say that motor-cars are quite as imperfect, and that the ingenuity of man could not devise a more efficient dust raiser than the modern motor-car, with its low body, trailing leather splash-boards and excessive speed.

As a road destroyer, after slight rain, just drying, or, worse still, after a sharp frost succeeding wet weather quickly and followed by a sudden thaw, a heavy motor-car traveling at 30 miles an hour will make grooves in an ordinary macadam road 5 in. wide and ½ in. deep, yet some people say motor-cars do not affect the roads prejudicially. We are not all motorists, and as these are primarily responsible for present trouble on urban and country roads, is it unreasonable to ask, that either the construction of motor-cars should be improved to prevent the damage they do to the roads, and worse still, the inconveniences they cause to the general public, and more particularly to the owners of and residents in houses abutting on those roads, or that they should at any rate help to pay for converting the roads to their use? Surely people who can afford to pay from £800 to £2,000 for a motor-car, and from £200 to £600 a year for its upkeep, can afford to pay a tax for their use of the roads, by which they absolutely take away all the pleasure which the ordinary pedestrian or driver of a horse used to find on the public highway.

I quite agree that the advent of the motor-car and other self-propelled vehicles has done some good, not only as regards urban but country roads. The old methods adopted by some rural councils of repairing roads with any kind of soft stone and binding it together with refuse obtained from wayside ditches has, it is hoped, gone forever.

I believe that motor-cars, motor vehicles, traction engines, tractors, and in fact every self-propelled vehicle which is firstly a public danger, and which secondly affects the public highways in such an extraordinary degree, should pay something.

Just look for a moment how severely handicapped is that self-propelled vehicle, an electric tramcar. Take a system operated by a company, say at Bristol: they have to not only make, but maintain, the paving of the road they run over; and they do not wear it out as they do not touch it. And they also pay rates on their buildings, plant, and track as any ordinary business concern does. Compare this with the ease with which an owner of a traction engine can pass into a neighboring county by paying a fee of 2s. 6d. and do £500 worth of damage.

Road engineers can make roads practically dustless, with a surface to suit the motorist and to stand fairly heavy traffic, but it amounts to a reconstruction of our country roads. This will cost money, and cannot be done without both rates and taxes. It would require that the ordinary rates for maintenance would be about doubled, and this would have to be supplemented by a sum of money being found from other sources, and the only source which will occur to most people is a tax on self-propelled vehicles. Mr. Asquith, the Chancellor of the Exchequer, stated last year when propounding his Budget that this tax had been suggested to him, and there is no doubt in most people's minds that such a tax will have to be imposed. There are at least 60,000 or 70,000 self-propelled vehicles in the country, and a tax of £20 per annum would realize from £1,200,000 to £1,400,000; and this should be collected by the State and handed over to the various authorities in proportion to their mileage and requirements. At the conference of road engineers and road users held last year under the auspices of the Incorporated Association of Municipal and County Engineers and the Roads Improvement Association a resolution was, I believe, practically unanimously carried that "a further tax beyond that at present imposed should be levied on self-propelled vehicles as a means of providing revenue for road maintenance purposes."

If, therefore, the present cost of the maintenance of roads in the counties is put at £1,500,000, and an additional £1,000,000 is obtained from rates, and, say, £1,250,000 from a tax of self-propelled vehicles, a sum of £3,750,000 per annum would be available, and with this sum the condition of the roads could be altered, not so as to make them perfect, but it would render their condition such that the present intolerable dust nuisance would be stopped. The change could not be a made in a year or in five years, but would be one of gradual growth, and the roads ought to be under some general system of inspection and control so as to insure that the money was spent on some system that would give the maximum amount of comfort for a minimum amount of expenditure. I am disinclined to suggest Government control, but rather a control of some board of engineers who have had large experience practically as road engineers. This subject of improvement in roads is not a political one, hence it has perhaps less chance of serious attention by Governments, whatever their politics may be, but when our politicians are quite tired of talking and abusing one another, and have settled the Irish, educational and licensing questions, let us hope they will be able to spend a short time in dealing with this question of roads improvement as a subject of national importance.

BESSEMER STEEL INGOT PRODUCTION in the United States in 1907 was 11,668,000 tons, including castings, against 12,276,000 tons in 1906. The production of Bessemer steel rails in 1907 was 3,302,000 tons as against 3,706,000 tons in 1906.

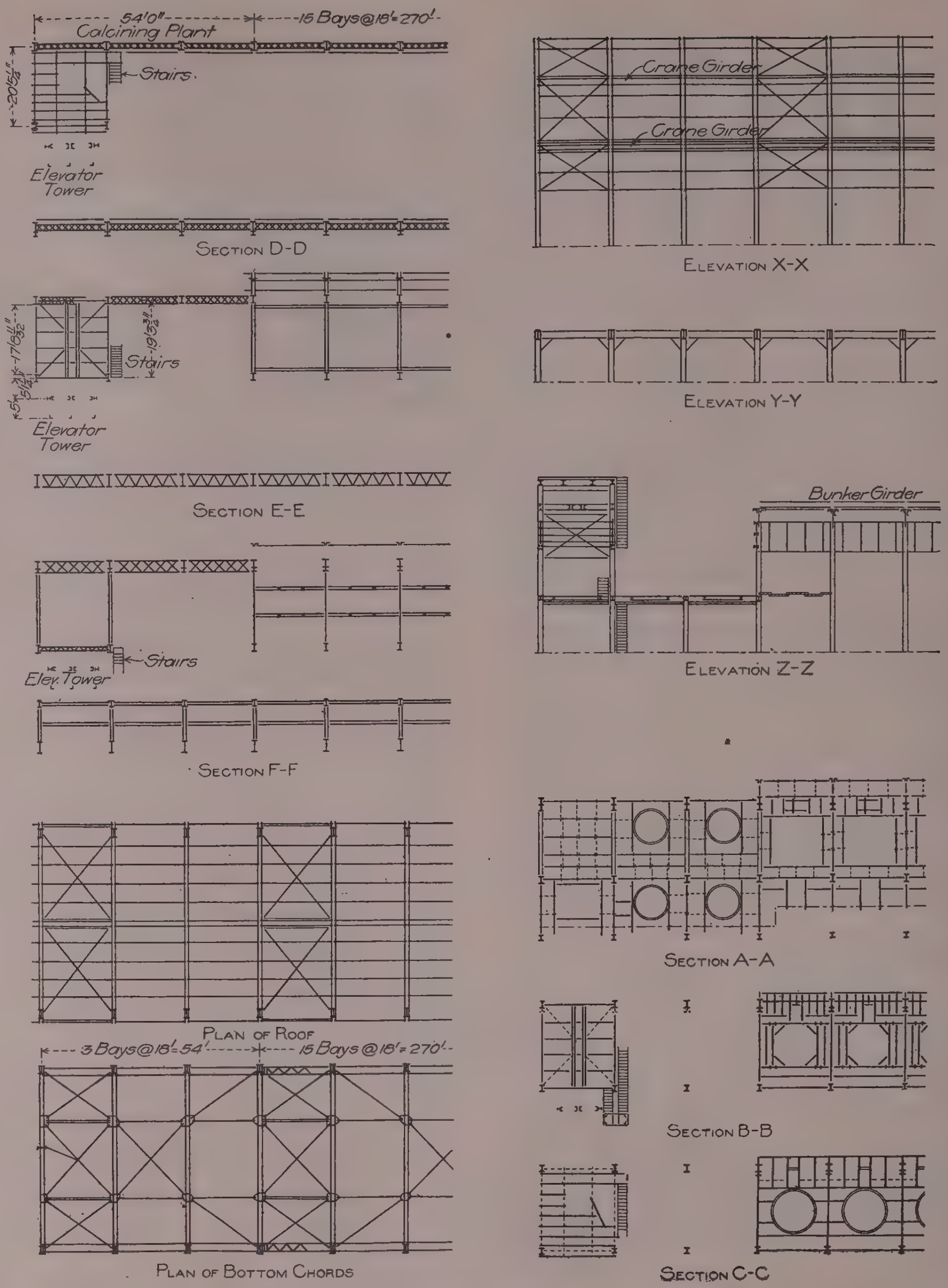
New Gas Producer Building, Pennsylvania Steel Works.

The five new 75-ton open hearth steel furnaces of the Pennsylvania Steel Co., at Steelton, Pa., are supplied with gas from an adjacent producer house with a capacity of about 1,460,000 cu. ft. per hour. The house is built entirely of steel and concrete and, like the open-hearth furnace house described in The Engineering Record of Feb. 29, 1908, is designed in accordance with first-class requirements for strength, economy and efficient details and to conform with the company's shop practice in methods of construction and use of standard and special machine tools.

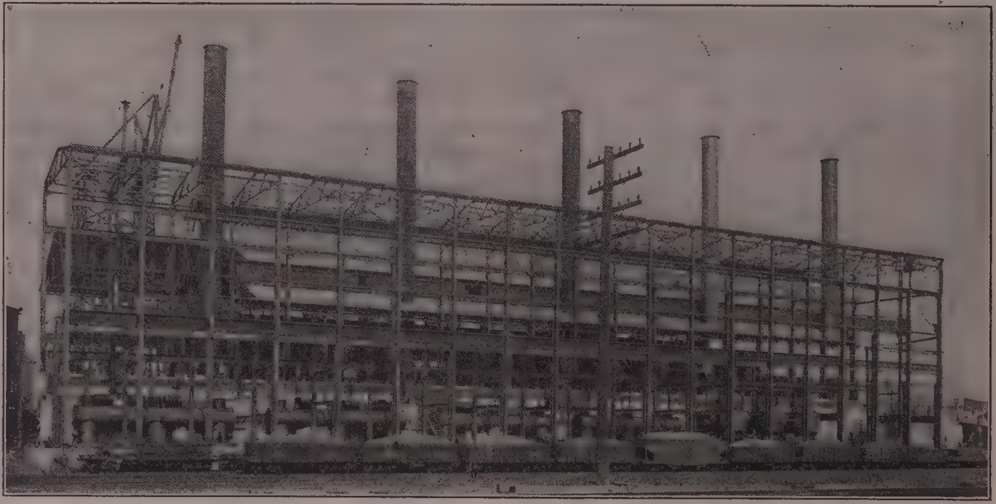
The building has a total length of 324 ft., a width of about 47 ft. over all and an extreme height of about 80 ft. from the base of the tallest columns to the apex of the roof and a clear height of about 46½ ft. from base of rail to lower chord of roof truss. There are 19 main transverse bents dividing the building into 18-ft. panels. Three bents and panels at the east end are special on account of the wall framing and hoist and bins for the dolomite and calcining plant, but the other 15 panels and the corresponding bents are regular as shown in the general plan and elevation diagrams and in the typical cross section.

The full length of the building is commanded by two 10-ton traveling cranes of 42 ft. span and 35 ft. clearance above a track which was carried the full length of one side of the building on a platform about 27 ft. above the surface of the ground, about 24 ft. above the lowest floor of the producer house. On the opposite side of the building there is a coal bunker 15 panels or 270 ft. in length concentric with a line of gas producers underneath, and having a clear height of about 35 ft. from the top of it to the lower floor under the gas producers. The bin has a cylindrical steel plate bottom and is supported by horizontal longitudinal girders carried on one side by the wall columns and on the other side by a row of interior columns about 35 ft. high. Another row of interior columns 13 ft. high carries the inner end of the transverse girders supporting the longitudinal girders for the track before mentioned.

Each intermediate transverse bent has a roof truss, four columns, and the beams and girders connecting them. The end bents have in addition two more intermediate columns. There are four panels of X-brace angles above the coal bunkers, and there are horizontal wall girts 4 or 5 ft. apart vertically. The bents are connected longitudinally by the track stringers, the coal pockets and its girders, longitudinal floor girders under the coal pockets, the traveling crane runway girders, wall girts and struts, and by 12 lines of 7-in. purlin channels. There is in each end panel and in four intermediate panels of the roof and wall columns X-bracing of single angles and additional bracing, in the plane panels of the bottom chords of the trusses, forming a continuous system for the full length of the building, all as indicated in the part diagrams of elevation and plan.



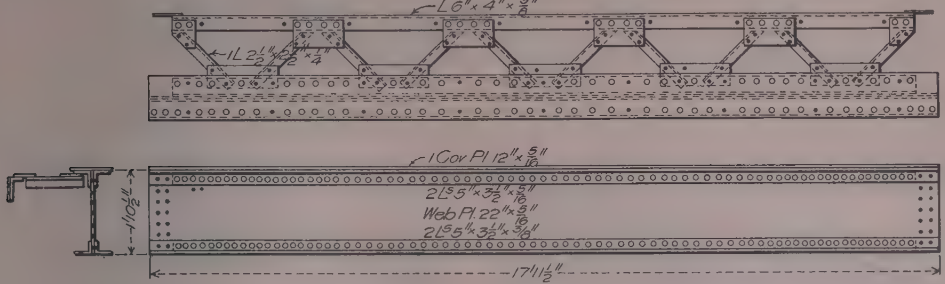
Vertical and Horizontal Sections and Elevations.



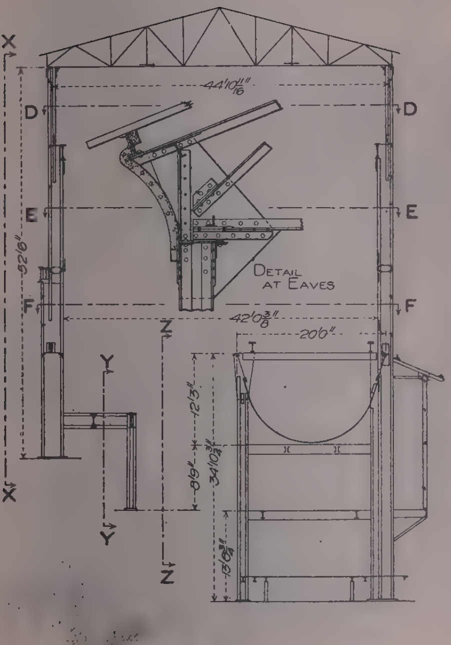
Framework of Producer House.

The calcining plant occupies three panels or 54 ft. at the east end of the building where the construction is special and very heavy to provide for the hoist, the dolomite bin and platforms and four furnaces of an inside diameter of 8 ft. 9 in., and a height of 20 feet. The hoist tower 62 ft. high, 5 x 10-ft., has six vertical columns supporting the elevator machinery and forming guides for the two cages. The center front column is made with a pair of 9-in. channels latticed and has a rectangular cross section and the two adjacent columns have a T-shaped cross section made with a 9-in. I-beam riveted to the back of the web of a 9-in. channel. The remaining three columns on the opposite side of the tower are single 6 x 6 x 7/16-in. angles, and the columns are latticed together on three outer faces of the tower with single 3 x 2½ x 5/16-in. angles.

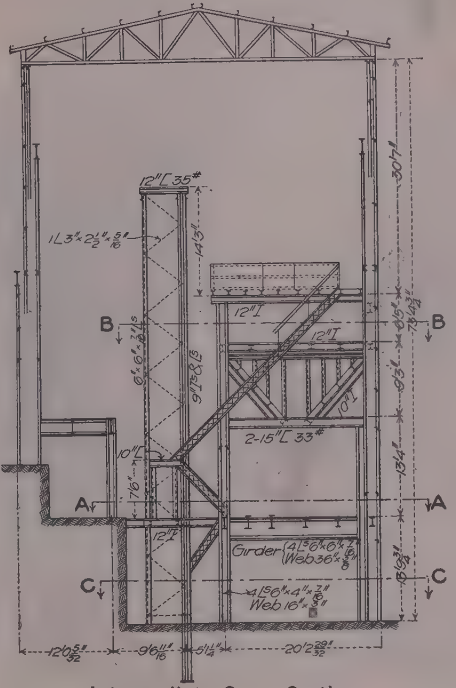
The hopper bottom dolomite bin is about 20 ft. square and 9 ft. deep with the lower edge 26 ft. above the ground. It has a framework of horizontal and inclined 9 and 10-in. I-beams and channels covered with 5/16-in. flat plates. Above the bin there is a heavy platform of longitudinal and transverse I-beams covered with solid flat plates and enclosed on three sides by a vertical wall about 3 ft. high of ¼-in. plates riveted to a framework of 3 x 2-in. angles. The platform below the bin is made with 15-in. and 20-in. longitudinal I-beams and 19 transverse plate girders. The track platform on the opposite side of the house is made with two lines of 24-in. plate girders 5 ft. apart, one line being supported directly by the short interior columns and the other being carried by the 25-in. transverse plate girders in the main bents.



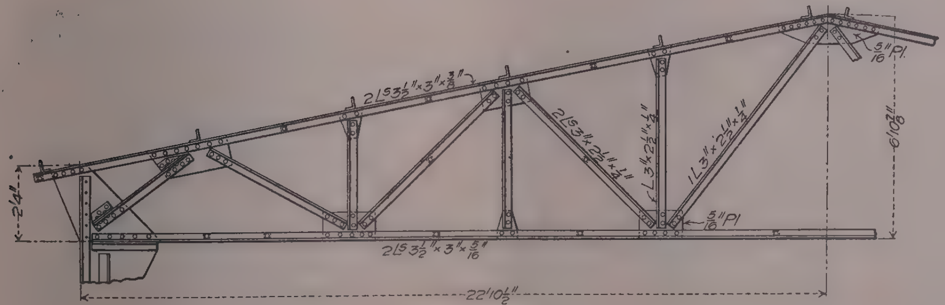
Crane Girder.



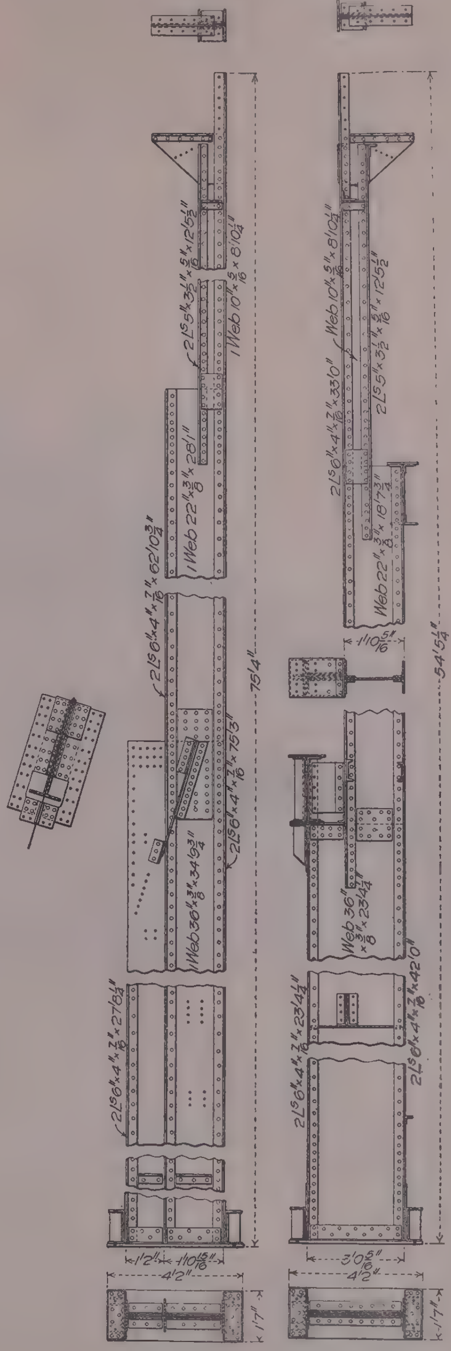
Transverse Section at End.



Intermediate Cross Section.



Roof Truss.


2Ls 5" x 3½" x 5/16" x 12'5½"
1 Web 10" x 5/16" x 8'10¼"
Web 10" x 5/16" x 8'10¼"
2Ls 5" x 3½" x 5/16" x 12'5½"
Web 22" x 3/8" x 28'1"
2Ls 6" x 4" x 7/16" x 35'0"
2Ls 6" x 4" x 7/16" x 62'10 3/4"
Web 22" x 3/8" x 18'7½"
1'10 5/16"
75'4"
54'5¼"
2Ls 6" x 4" x 7/16" x 75'3"
Web 36" x 3/8" x 34'9¼"
Web 36" x 3/8" x 23'4¼"
2Ls 6" x 4" x 7/16" x 27'0¼"
2Ls 6" x 4" x 7/16" x 23'4¼"
2Ls 6" x 4" x 7/16" x 42'0"
1'2"
1'10 5/16"
4'2"
3'0 5/16"
4'2"
1'7"
1'7"

South and North Wall Columns.

All columns have I-shape cross sections with their webs in the transverse planes of the main bents. The most important ones are those in the south wall which support the coal pocket, the traveling crane runway girders and the roof trusses. The webs are in three lengths spliced with double shop-riveted cover plates. The lower part of the column has a 36 x ⅜-in. web plate nearly 35 ft. long with four 6 x 4 x 7/16-in. flange angles, two of which, on the inner side, terminate just below the coal pocket, while the other two, 75 ft. long, are continuous the full length of the column, thus helping to splice the web plates of the successive sections. There are also two more 6 x 4 x 7/16-in. angles about 63 ft. long which reinforce the web of the lower part of the column near the center line and extend to the top of the crane girder forming the inner flanges of the second section of the column.

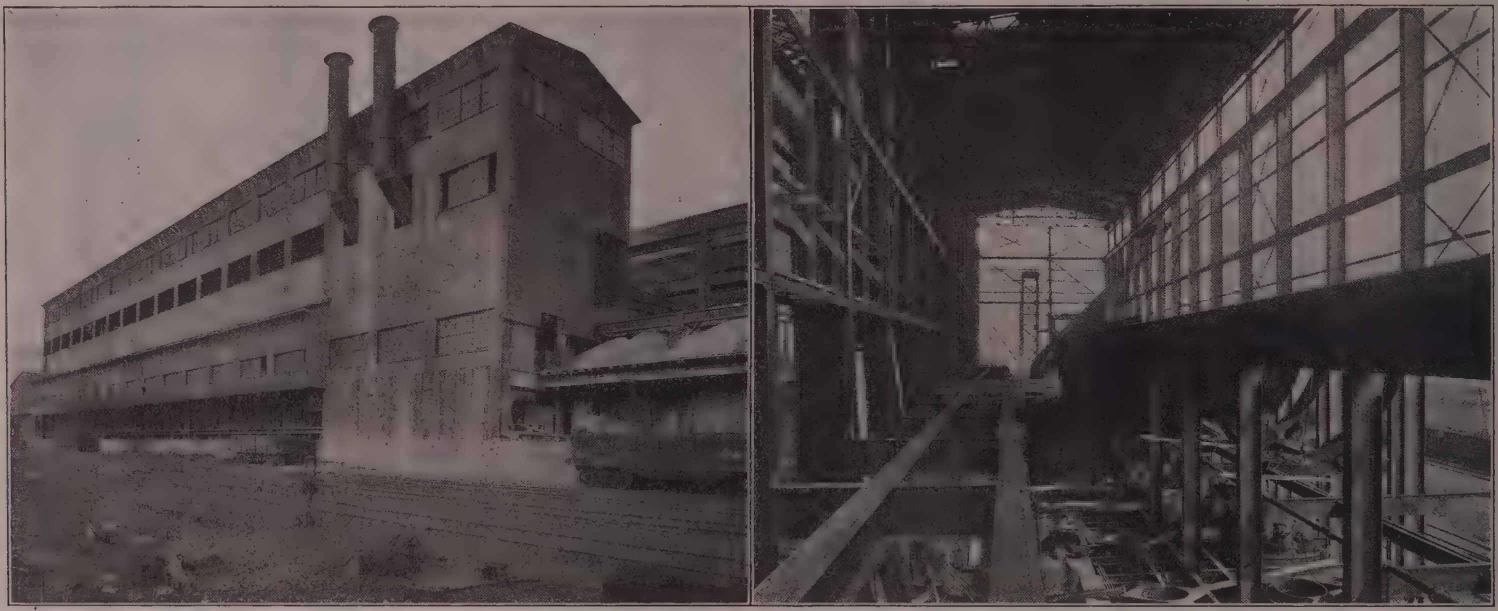
The second or middle section of the column has a 22 x ⅜-in. web plate about 28 ft. long and the third or upper section has a 10 x 5/16-in. web plate about 9 ft. long with two 5 x 3½ x 5/16-in. inner flange angles continued 2½ ft. below the top of the second section of the columns at the level of the top of the crane girder, thus stiffening the column web and forming a part of its splice. The appearance of the column is rather peculiar on account of the three offsets provided by its webs of different widths and the special connections to the other principal members of the framework.

The horizontal coal-pocket girders with inclined webs have their ends abut against the column webs and are field-riveted to a connection angle shop-riveted to the latter. The runway girders for the traveling cranes instead of being seated on horizontal caps of the offset lower portions of the column webs are field-riveted through their webs to the inner flanges of the columns and the ends of the roof trusses have their lower chord flanges seated on and field-riveted to horizontal flange angles on the upper edges of knee-brace or connection plates which form short extended sections of shop-riveted sections of the column webs.

The columns in the opposite wall of the building resemble those already described in that their webs are made with two offsets, and that the connections for the roof trusses and for the interior traveling crane runway girders are the same. They differ from them in that there are no connections for coal-pocket girders and in that the lower sections of the web are offset on opposite sides of the center part, thus affording a horizontal seat on the outer flange of the column for runway girders of an exterior traveling crane. The maximum stresses in these columns are only 230,000 lb., as compared with

300,000 lb. in the coal pocket columns and the cross sectional area is accordingly reduced from 39 sq. in. to 30 sq. in. at the foot by the omission, below the tops of the first section, of the two 6 x 4-in. inner flange angles of the second section of the columns which in the coal pocket columns form central reinforcement for the lower section of the column.

The runway girders for the interior crane have a 22 x 5/16-in. web plate and pairs of 5 x 3½-in. flange angles ⅜-in. thick for the bottom and 5/16-in. thick for the top flange, which is reinforced with a 12 x 5/16-in. cover plate receiving the connections for 2½-in. zigzag lattice angles which brace the top flange to a 6 x 4 x ⅜-in. horizontal angle connected to the outside flanges of the column and thus forming a horizontal truss about 30 in. deep over all. The runway girders for the two outside traveling cranes, each of 10-tons capacity, have 24 x ⅜-in. webs and pairs of 5 x 3½ x 7/16-in. flange angles reinforced, for the top flange, by one full length 14 x ⅜-in. cover plate. The lower flanges are provided at both ends with sole plates through which they are field riveted to the horizontal seats in the column offsets, and the end vertical web stiffeners of adjacent girders are field riveted together through vertical transverse diaphragms projecting from the columns.



Exterior and Interior of Gas Producer House.

The coal bunker girders have inclined 48 x ⅜-in. full length webs with 26 field-driven rivets in each column connection. The bottom flange, not being designed to resist any lateral or transverse stresses is composed of one 9 x 9/16-in., and one 6 x 9/16-in. web plate, the former like the web, being provided with a continuous single row of open holes for the field-riveted connection to the curved bottom plate of the bunker. The top flange corresponds to that of an ordinary plate girder and is made with two 6 x 4 x 7/16-in. angles.

The roof trusses 45 ft. 9 in. long and about 7 ft. deep over all weigh 2,500 lb. each and all of their members have T-shaped cross sections made with pairs of angles riveted back to back with connection plates between. The end connection plates provide for the overhanging top flange and a concave cornice made of reinforced concrete and are field-riveted between the projecting upper ends of the outer flange angles of the column.

The total weight of the structural steel in this building is about 1,604,000 lb. The work was done under the direction of Mr. E. C. Felton, president, and Mr. J. V. W. Reynders, vice-president, and the steel superstructure was designed, manufactured and erected by the Bridge & Construction Dept., Mr. Thomas Earle, superintendent, Mr. F. C. King, chief engineer, and Mr. F. W. Cohen, engineer of erection.

Riveted Joints.

The strength of riveted joints as influenced by the commoner defects in riveted work was investigated at the University of California in 1906, the tests not being designed to determine efficiency or proportions. The results are published in the "California Journal of Technology," from which these notes were taken. The series contained joints with various defects, but the materials were all the same, consisting of ½-in Carnegie tank-steel plates, and ¾-in. soft steel rivets of Carnegie manufacture. The holes were 13/16 in. in diameter. Lap joints of two styles, each containing two rivets, were used. The first style had the rivets 2¾ in. center to center on a line perpendicular to the line of stress, and in the other style 2½ in. center to center in the direction of the stress. All joints were designed to fail in the rivets. The stress was applied in increments of 1,000 or 2,000 lb. and, except in special cases, carried to failure without stopping the machine. Rivet failure was always in shear with a silky fracture. The report of the tests closes with the following summary: "1. That the strength of rivets in a joint having holes punched without reaming is greater, rather than less, than in one in which holes are punched small and reamed to size. 2. That the exact temperature of the rivet or of a particular part of it is immaterial to the strength of a joint. 3. That a maintenance of presure for 30 sec. materially increases both the strength and rigidity of the joint—the first sometimes by as much as 40 per cent. 4. That rivets burned so that they spit when taken from the fire do not necessarily cause a weakness in the joint, although they do not properly fill their holes. 5. That a rivet 3/16 in. smaller than the hole which it is to fill, will fill the space tolerably well though not perfectly. 6. That joints in which the holes are not perfectly concentric lack rigidity, but give ultimate strengths about up to standard. 7. That the shearing value of a rivet is materially greater after driving than before, this probably being due to increased cross section."

The Blackwell's Island Bridge over the East River at New York had its cantilever arms over the main channel between Manhattan and Blackwell's Islands joined this week.

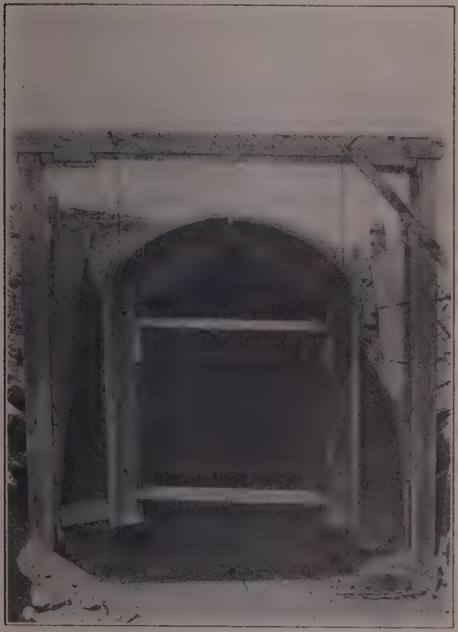
Test of Volute Pump.

An efficiency test of an oil-burning pumping plant for rice irrigation was made last summer near Jennings, La., for the Jennings Canal Co., by Prof. W. B. Gregory, irrigation engineer, Department of Agriculture, the results of which are given in the "Sibley Journal of Engineering." The plant is used for supplying water to 2,000 acres of land, and consists of a Worthington horizontal-shaft, volute, single-suction centrifugal pump, having a 30-in. suction pipe, driven by a Hamilton tandem compound condensing four-valve engine, taking steam from a Babcock & Wilcox boiler. The pump discharges upward through an expanding nozzle, 30 in. in diameter at the pump, and with more than double the area of the lower end at the point where it discharges into the flume, so that the velocity is much reduced. The normal capacity of the pump is 22,000 gal. per minute. The engine is 12 and 24x24 in. A Dean independent jet condenser was used. The boiler had 1,550 sq. ft. of heating surface. A Cochrane heater raised the feed water from 80° to 170° Fahr. The fuel was crude oil costing $0.95 per barrel of 42 gal. at the plant. The heat value was 18,922 B.t.u. per pound. The burner was a Peabody No. 1. As the boiler was of the cross-drum type with small water-storing capacity, the length of the test, 4 hr., was considered satisfactory. The amount of fuel oil per useful water horse-power-hour was 2.16 lb. The total fuel oil burned was 1,344 lb., and the boiler efficiency 75.5 per cent. At a speed of 187.7 r.p.m. the average useful water horse power was 155.7 and the efficiency of the engine and pump 75.4 per cent. The cost of the fuel per hour was about $1 (1.05 bbl.), and the cost to raise 1,000,000 gal. one foot, 2.68 cents. The duty in millions of foot pounds of useful work per 1,000 lb. of steam was 67.7.

The Famous Board Walk at Atlantic City is to be reconstructed in part, and located from 300 to 500 ft. nearer the ocean than its present site. This shifting of position is due to the fact that the beach has been building up during the past four or five years. In the reconstruction, concrete piles 16 in. in diameter and 28 to 32 ft. long will be used. These will be arranged in bents of either two or four and capped with a reinforced concrete girder 24 in. deep and 8½ in. wide. The contract for the work has been awarded to the Raymond Concrete Pile Co., and calls for 800 ft. of walk 41 ft. wide and 2,400 ft. of walk 21 ft. wide.

The Water-Supply System of Salt Lake City, Utah.

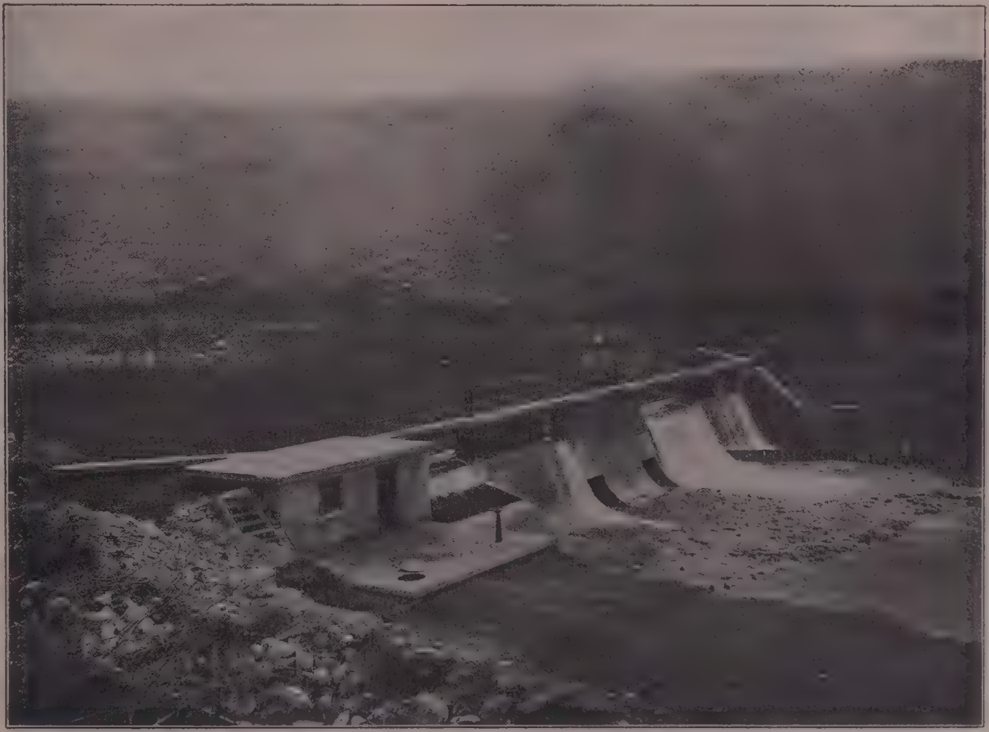
The water supply of Salt Lake City, Utah, is obtained from several mountain streams through a combination of water rights which are believed to be peculiar to that locality. The city is on a sloping plain close to the westerly base of the foot-hills of a range of mountains that extends nearly north and south, with the Great Salt Lake a few miles to the west. The annual total precipitation in the surrounding region has varied from 21 in. as a maximum for the period from 1874 to 1878 to between 15 and 16 in. for the past 20 years. The rainfall during the summer is especially light, the average for the four months from June 1 to October 1 of each year from 1874 to date having been not more than 3 in. These rainfall conditions, coupled with the fact that the adjacent country is intensely cultivated under irrigation, render exceedingly valuable the rights to divert water from the streams which have their sources in the mountains. The municipal supply has, however, always been obtained from these streams because the water from the latter is particularly pure and cold, while all other available sources are objectionable, from one cause or another, for domestic consumption.


Forms for Big Cottonwood Conduit.

The original mountain water supply was obtained from City Creek and Emigration Creek, two small streams which have their sources in the mountains and flow through the city into the Jordan River. The supply available from these two streams was delivered by gravity to the distribution system of mains by two separate conduits. The quantity available from these two streams long ago became inadequate, so additional supplies had to be obtained. The closest stream of any considerable flow was a creek in Parley's Canyon, which creek extends along what is now the southern boundary of the city. The waters of this creek were fully appropriated, however, for irrigation purposes. Nevertheless, the city obtained rights to a large percentage of the flow by exchanging water from Utah Lake, a broad body of fresh water 25 miles south of the city, for the quantity diverted from the stream. Later, when the supply again became inadequate, this exchange of rights was further extended in order to permit the diversion of water from Big Cottonwood Creek, a stream of considerable size some 10 miles below the city. Plans have been perfected, also, to continue the extension of this exchange for more water from this and other streams, so the city is thus assured of a sufficient supply for many years, while the possibility of constructing storage reservoirs on the watersheds of the different streams will render available all the water necessary for any demands that may be expected.

The conditions involved in the exchange of water rights in a semi-arid region similar to the one surrounding Salt Lake City, where the irrigation of the land has given a very great value to these rights, are particularly acute. The waters from the streams now used chiefly for the municipal supply have been diverted during the past forty years to irrigate an area of about 17,000 acres. The land comprising this area is owned in small tracts of about 15 acres each, and is generally in a high state of cultivation. Most of the area is devoted to the production of fruits, vegetables, sugar beets and alfalfa hay, and with sufficient water for irrigation yields abundantly. The average value of the land and improvements is about $175 per acre, making the whole area worth nearly $3,000,000.

Construction of Conduit.


Diverting Dam at Head of Big Cottonwood Conduit.

The water from all of the mountain streams is pure and clear, but its temperature is too low and its flow too variable to best serve the purposes of irrigation. On the other hand, for domestic consumption and municipal uses the water is well suited and is also favorably situated. Incidental to its use for irrigation, the mountain water was also formerly used for culinary and other domestic purposes by all those living on the irrigated land. This incidental use is still continued on the upper portions of the area described, but on the major part of the area lower down flowing wells now furnish water for domestic purposes. The dependable flow from City Creek, Parley's Creek and Big Cottonwood Creek combined is about 50 cu. ft. per second in seasons of low water. At flood stages the flow is perhaps as much as 900 cu. ft. per second. A low flow generally occurs late in the irrigation season with the result that, when depending on the streams, the maturity of a full crop on all the land under irrigation is never realized.

The water from Utah Lake, on the other hand, is turbid and much warmer than the mountain water, which with other conditions render it entirely unsuited for domestic consumption, although quite preferable to the mountain water for irrigation. Furthermore, the lake is at so nearly the same elevation as the city that water cannot be delivered from it to the latter by gravity under sufficient head to preclude the necessity of pumping into the distribution mains. At the same time, the lake is sufficiently above the irrigated areas formerly dependent entirely on the mountain streams that water can be delivered to that area from the lake by gravity. A canal was built from the lake to the city by the latter about 25 years ago, and the city owned sufficient rights in the waters of the lake to divert enough water into this canal to irrigate practically all of the area dependent on the mountain streams. Notwithstanding the fact that all physical conditions were thus favorable to an exchange of rights, the prejudices and other circumstances surrounding the ownership of the rights in the streams made arrangements for such an exchange difficult to consummate. These prejudices and circumstances unfavorable to an exchange of rights have, never theless, been overcome sufficiently to obtain all the water from the mountain sources necessary for any demands that may be expected in the near future. By the purchase of rights on the streams and by exchange of lake water the flow of the mountain water can later be rendered almost entirely available for municipal consumption.

The first water rights to be acquired by the city through the medium of exchange were those of the farmers who originally appropriated water from Parley's Creek for irrigation. The contract under which this exchange was made is dated June 25, 1889, and its general terms are that the city shall divert and use a portion of the flow of the creek in exchange for a substituted supply to be turned into the farmers' ditches through the municipal canal from Utah Lake. The contract provides that the flow of the creek shall be measured twice each irrigation season; that the quantity of flow at the first measurement shall be that which must flow constantly from the municipal canal into the farmers' ditches during the period between the first and second measurements, and that the quantity of flow at the second measurement shall be that which must flow into the ditches from the canal during the remainder of the irrigation season. The farmers thus enjoy the advantage of an undiminished flow throughout the periods succeeding each measurement made, while the flow received by the city from the creek in exchange diminishes daily throughout the same periods. The flow to the city, however, is continuous throughout the year, while the period of flow to the farmers is limited to the irrigation season of about 150 days.

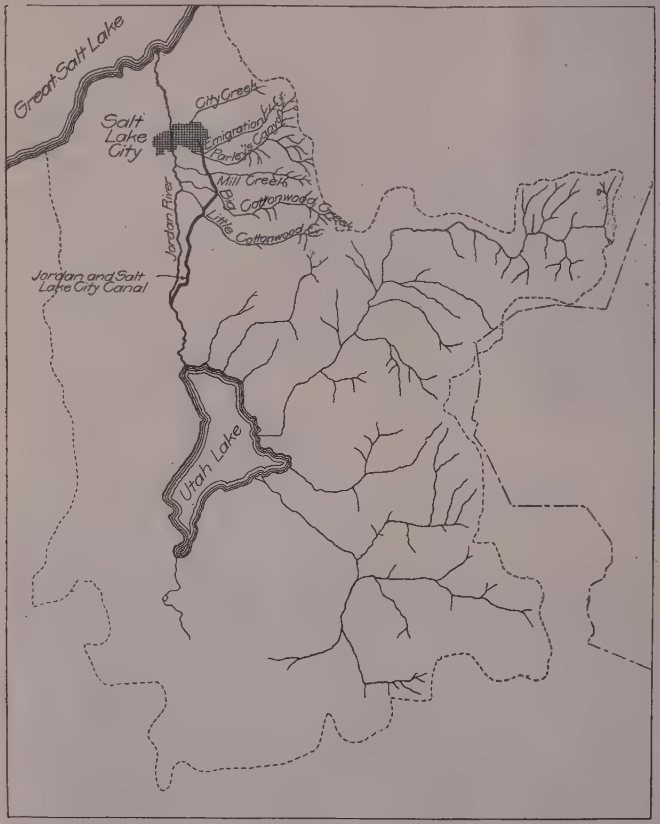
Although this plan of procuring water for municipal purposes is, perhaps, peculiar to Salt Lake City, the situation and controlling circumstances are such as to compel the unusual methods. The price of the land and improvements which would have to be included in the cost of rights to divert water from the intensely irrigated lands are prohibitive. At the same time, the greater portion of the city's supply of water was provided in pursuance of the terms of the contract for the waters of Parley's Creek for 18 years prior to the completion of a conduit to convey water to the city from the Big Cottonwood Creek. During this time, also, the supply has been equally as regular and dependable as from other sources of supply in which the city is absolute owner. Based on this result, the city procured rights to thirty-sixtieths of the flow of the Big Cottonwood Creek in exchange for the lake water. A course to acquire in a similar way the right to use this entire stream as well as to parts, or all of the Little Cottonwood and Mill Creeks, two adjacent streams, is being persistently pursued.

Utah Lake Pumping Station. Utah Lake is a shallow body of water with a maximum width of 12 miles and a maximum length of 23 miles, that is fed by several mountain streams, and also has some connection with underground watercourses. The level of the lake is naturally controlled by the rainfall conditions and varies as much as 5 ft. When at the higher levels, the lake overflows into Jordan River, which carries this overflow into the Great Salt Lake, some 30 miles distant; at periods of low water in the lake, however, this stream is naturally dry. The flow in the river has for many years been diverted for irrigation purposes, most of the land thus supplied being formerly cultivated during years of more favorable rainfall. In order to overcome the deficiency of flow in the river during dry years a pumping station was installed at the head of the Jordan River in 1902. The equipment of this station is arranged to lift the water from the lake and discharge it into the river when the lake level is too low to cause such a flow naturally. The flow of the river is diverted into five different irrigation canals below the station, one of which is the one built by Salt Lake City.

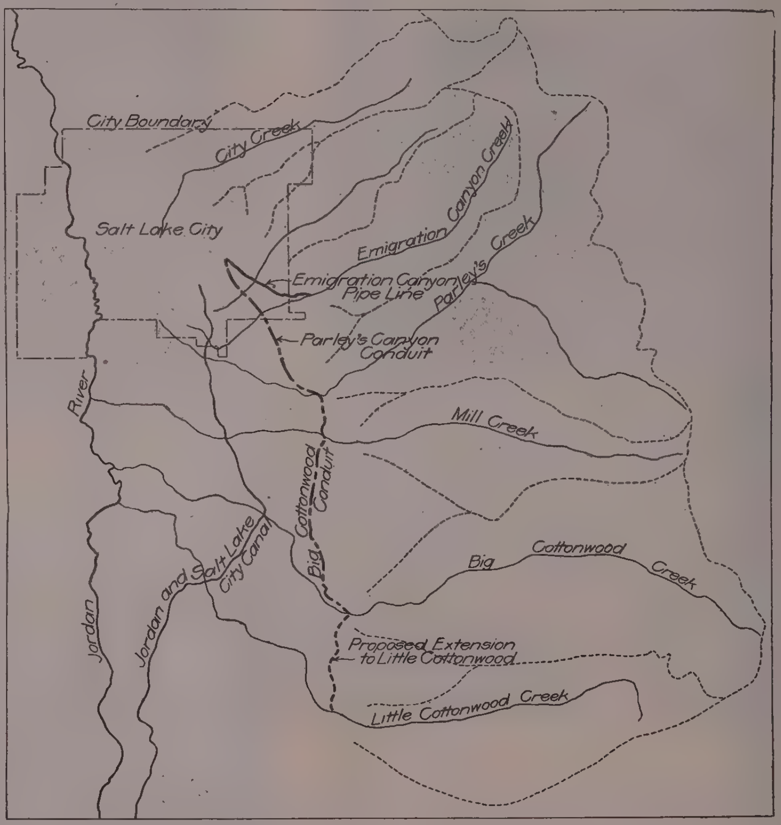
The pumping station is owned by five irrigation companies, four of which are made up of the farmers along the canals and the fifth is Salt Lake City; the latter also owns a one-fifth interest in one of the private companies. The station contains seven 40-in. Byron-Jackson electrically-driven centrifugal pumps, with a normal capacity of 100 cu. ft. per second each, thus making the output of the station over 450,000,000 gal. per 24 hr., which is believed to be the largest of any water-supply pumping station thus far built. The first four pumps installed are owned jointly by the five companies, while four of the companies own a one-quarter interest in two of the other pumps, and the seventh is owned by three of the companies. The city, therefore, is interested in all seven of the pumps.

The first five pumps installed were in a row in the concrete substructure of a 103 x 34.5-ft. building. Three pumps were placed on a floor 5.5 ft. below a level in the lake established by compromise, which level has been exceeded by as much as 2.05 ft. by the stage of water in the lake. Each pump is of the double-suction type, and operates against a head of from nothing to a maximum of 5 ft. The inlet connections on the lake side and the discharge pipes on the river side are each provided with a flap valve to prevent back-water from either direction from flowing through the pumps. Each of these five original pumps is belt-driven by a 100-h.p., 440-volt, Type K Westinghouse alternating-current continuous-speed motor.

The two additional pumps have only recently been installed and are of the latest improved pattern 40-in. Byron-Jackson centrifugal type. These pumps are in a 49.5 x 25-ft. addition to the original building, which addition, like the original building, has a heavy concrete substructure on a pile foundation. Each of the pumps is geared through a shaft carrying a friction clutch to a 150-h.p. 440-volt alternating-current continuous-speed Fairbanks, Morse & Co. motor. These motors are at the same level as the pumps, the pit being made water-tight. The shaft of one of these new pumps is also arranged with a second friction clutch so it can be driven by a 130-h.p. four-cylinder tandem-compound two-cycle gasoline engine, built by the Jacobson Gas Engine Co. This engine was installed by the city in order that the one pump could be operated in case the supply of electrical power is interrupted. Sufficient water can thus be delivered to the river at all times to supply the amount necessary to exchange for the quantity diverted from the mountain streams. Since the flow in the river is sufficient, however, to supply all of the canals during years when the



Map of Vicinity of Salt Lake City.

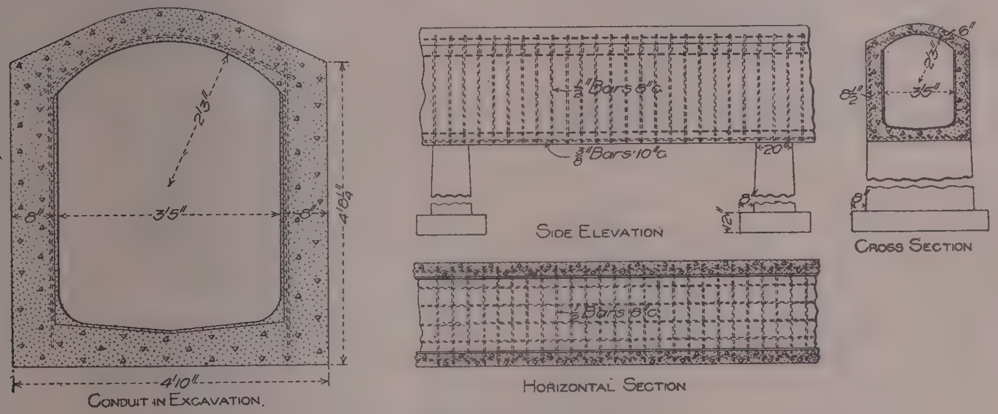


Sources of Water Supply for Salt Lake City.

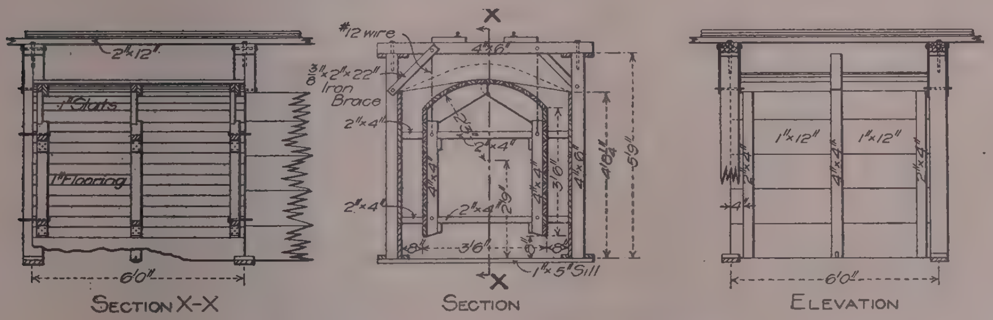
rainfall is above the normal, the station is frequently idle for considerable periods, but is always necessarily maintained in readiness to operate.

The electrical power used to operate the station is obtained from a hydro-electrical development at the foot of the mountains, 19 miles away. Current is transmitted from this development to the station at 5,000 volts over a pole line, and is stepped down to 440 volts by a bank of five 175-kw. oil-cooled transformers in a row of separate brick cells outside the station building. The operation of the motors is controlled from a switchboard in a separate room between the old and the new parts of the station building.

Water is diverted from the Jordan River into the municipal canal through headworks in a dam about 12.3 miles below the pumping station. This canal is 24.5 miles in length, extending down the right side of the river to the city. It was built to deliver the lake water directly to the city and as such has served the purpose well; but its capacity is not great enough to supply lake water in exchange for mountain water from the Big. Cottonwood Creek and other similar sources. The location of this canal is also such that it cannot be made to deliver exchange water to all the land from which the mountain water can be procured by substituting lake water. The East Jordan canal, another irrigation canal, is located, however, on the same side of the river and the city owns a one-fifth interest in this canal, which has a right to 170 cu. ft. per second from the lake. This canal is located on the highest contour along which it is possible to convey water from Utah Lake by gravity, and throughout its entire length of 18.5 miles is parallel with, and 55 ft. in elevation above the municipal canal. Plans have been consummated whereby the first 19 miles of the municipal canal, extending to the crossing of Big Cottonwood Creek, may therefore be abandoned by enlarging and extending the East Jordan canal to carry the entire city exchange supply in addition to the supply for the private canal. An extension from Little Cottonwood Creek to Big Cottonwood Creek capable of carrying the city's supply would then discharge into the latter creek and from it be recovered into the farmers' ditches and into the remainder of the city canal.



Details of Big Cottonwood Conduit..



Details of Forms for Big Cottonwood Conduit.

Conduit System. The oldest conduit which delivers water to the distribution system is a 12-in. wood-stave pipe line 1.5 miles long, leading to that system from City Creek, northeast of the city. The surplus carried by this conduit is delivered to three storage tanks, with a combined capacity of 325,000 gal.; these tanks act as pressure and supply regulators. The second oldest conduit is a 12-in. Kalamined pipe line, about 3⅛ miles long, which extends from an intake on Emigration Creek to a 5,000,000-gal. distribution reservoir on the hills to the east of the central part of the city.

The water of Parley's Creek is delivered into the city by a 36-in. concrete conduit, 5.1 miles in length, which extends from a diverting dam on the creek to the same 5,000,000-gal. reservoir into which the Emigration Creek conduit delivers. A 1,690,000-gal. reservoir is placed in the canyon of Parley's Creek, at the diverting dam, in order to provide for daily fluctuations in demand and for sedimentation. This reservoir was created by a masonry dam across a narrow part of the canyon and has recently been lined with concrete. A wood-stave by-pass has also been built around the reservoir, in order that the latter may be cut out of service if desired.

The conduit which has recently been built to deliver the water from Big Cottonwood Creek to the city has a total length of 38,167 ft., or 7.23 miles, extending from a diverting dam and headworks near the mouth of the canyon of that creek to a connection with the conduit which extends from the reservoir in Parley's Creek canyon to the city. This new conduit is of reinforced concrete and crosses Mill Creek, arrangements having been made to divert the waters of that stream into it. Plans have also been prepared to extend the conduit 4.5 miles beyond the present upper end to the Little Cottonwood Creek. The conduit, as built, has a capacity for carrying 39,000,000 gal. of water per 24 hr., which is probably as much water as can be obtained from the three streams.

The diverting dam and headworks of this conduit on the Big Cottonwood Creek consist of a gravity-section overflow concrete dam, with a screen and gate chamber in one end which connects with the conduit. The dam is 11 ft. high above the base and 94.5 ft. long at the crest. In order to prevent underflow a cut-off wall 4 ft. wide was extended 22 ft. below the footing, flush with the up-stream side of the dam, the latter being on a deposit of gravel and boulders mixed with clay. A 12-in. apron of concrete was also extended down-stream 6 ft. 4 in. to avoid scour in the bed of the stream. The overflow crest of the dam is controlled by two Cippoletti adjustable steel weirs, which permit the amount of opening to be varied and the flow of the stream to be measured. The flow over one half of the dam may be diverted into the screen chamber of the conduit through one weir opening, or that weir may be moved so no water reaches the chamber. Two 3.5 x 3.5-ft. openings through the dam are placed near the bottom of the latter, between the two weirs, and are each provided with a sluice gate so the reservoir above the dam may be flushed out. These two gates and the weirs are controlled from a concrete footway carried longitudinally over the crest of the dam by two I-beams.

The designs and construction of the conduit were described briefly in The Engineering Record of July 13, 1907. The conduit follows a hydraulic gradient along the side of the foot hills from the diverting dam to Parley's Canyon. Two different sections were used for the conduit in this distance, the one first adopted being rectangular, while the second has an arched instead of a flat roof, both sections being 3.5 ft. wide. A length of only about 1,050 ft. of the rectangular section, which is 4 ft. high, with the invert depressed 2 in. at the center by making it 8 in. thick at the sides and 6 in. thick at the center, was built. The side walls of this section are 6 in. thick, and the flat roof from 4 to 6 in. thick, according to the depth of cut in which the conduit was built. In the arched section the invert is the same as in the section which it superseded, except that the corners between the invert and side walls were rounded to prevent lodgement of impurities. The thickness of the side walls was also increased to 8 in. The arch roof was increased to a thickness of 6 in. at the center and given a rise of 10.3 in., the skewbacks being made 10.3 in. deep. The sides and invert are plastered with a ½-in. coat of cement mortar.

The side walls are each reinforced under normal conditions with a row of ⅜-in. bars placed ½ in. from the inner face of the wall and spaced 6 to 8 in. apart. The arch is reinforced with a row of ⅜-in. bars, spaced the same as those in the side walls. In various places where the conduit crosses small watercourses, or depressions below the hydraulic grade, it is carried on concrete piers above the level of the ground. In such cases ½-in. rods, 8 in. apart on centers, were used in the side walls and arch, and the invert contains ⅜-in. longitudinal bars placed 10 in. apart on centers.

The concrete piers on which the conduit is carried over the small watercourses and depressions have a cross section at the top 20 in. wide and of the same length as the width of the conduit, the sides of the piers being built on a batter of one-half inch to one foot. These piers are on a footing course 12 in. thick and 8 in. wider on all sides than the base of the pier. They are spaced 15 ft. apart on centers and were built in advance of the conduit, in order to form a true joint between them and the bottom of the latter, thus allowing for movements due to temperature changes. Since the conduit is covered with at least 2 ft. of soil in all exposed places and the water which it carries varies only slightly in temperature, any such movement is slight.

The conduit is laid on a 0.12 per cent. grade to Mill Creek and thence on a 0.15 per cent. grade to within 800 ft. of the connection to the Parley's Creek conduit. The carrying capacity is 32,000,000 and 39,000,000 gal. per 24 hr., respectively, for the two different rates of grade, thus providing for the admission of water from Mill Creek. In the last 800 ft. the conduit drops 180 ft. over the side of a steep hill by means of a series of short sections with varying grades. Three blow-off connections with mud drums are provided at convenient points along the conduit to allow the latter to be drained for cleaning or in an emergency.

A wagon road had to be built along the entire line of the conduit so construction materials could be delivered, as the location is for the most part well up on the steep sides of the foot hills isolated from any means of transportation. The concrete was made of Utah Portland cement, sand and gravel obtained from pits adjacent to the conduit in the proportions of 1:2.5:4.

The concrete was made in a Smith concrete mixer set up over the site or immediately at one side of the conduit, at intervals of about 1,000 ft., and at points where materials could be readily supplied to it. The details of the concrete forms are shown in an accompanying illustration. The concrete was delivered from the mixer to place in four-wheel ½-yd. steel dump cars running on a 24-in. gauge track laid on planks carried by 4 x 6-in. caps on 4 x 6-in. posts of the forms.

The forms were built so the concrete in the invert, side walls and arch could be deposited simultaneously. The wall forms were built in sections 6 ft. long and were hung by wires from the 4 x 6-in. caps carrying the car track.

The ribs of the arch form seated on vertical posts of the inner forms of the walls, so the core of the form could be swung and blocked in position readily. Then, when the concrete had set, the side and arch forms could be easily removed by clipping the wires supporting the sides.

The distribution mains to which the Parley's Creek conduit delivers had an actual capacity of only 7,500,000 gal., and as the flow in City Creek is decreased at times to less than 3,000,000 gal. per day, the total possible supply that could be delivered was less than 10,000,000 gal. In order, therefore, to make available for distribution the 20,000,000 gal. of water capable of being delivered at the end of Parley's Creek conduit after the completion of the new Cottonwood Creek conduit, a new main, 2.08 miles long, consisting of 0.75 miles of 36-in. cast-iron pipe and 1 1/3 miles of 30-in. cast-iron pipe, has recently been laid from a point on the Parley's Creek conduit into the city. The upper end of this main is 447 ft. above the center of the city, so a pair of 24-in. pressure regulator valves were placed on it at a point where the pressure rises above desirable operating conditions. These regulators are between two Y-connections and are in a concrete gate chamber, 10 x 18.5 ft. in plan. A hand-operated gate valve is placed on each side of both regulators and an air valve is provided on the down-hill side of the pair. The sides of the chamber are carried 10.25 ft. above the ground level on the down-hill side and are covered with a flat concrete roof reinforced with I-beams. A two-wheel traveling crane is suspended over the longitudinal center line of the house on a 4-in. gauge track carried by a pair of 10-in. 35-lb. channels hung from the I-beams of the roof.

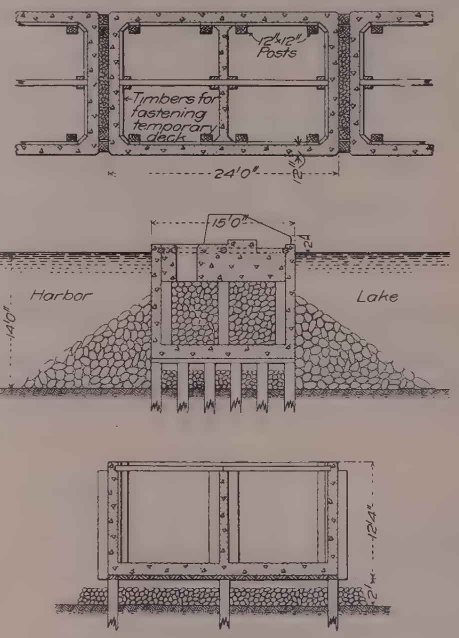
The water-works system of Salt Lake City is under the supervision of Mr. Louis C. Kelsey, city engineer. Mr. Geo. O. Chaney is principal assistant engineer; Mr. A. F. Doremus is assistant engineer in charge of the exchange of water rights and Mr. L. L. Parke is assistant engineer of the water-works division.

A Pipe Coil Radiator without threads has been devised for use in temporary heating installations. It is made up with fittings, reamed tapering, into which the pipe ends, turned to corresponding tapers, are snugly driven. The coils are found to be steam-tight under low pressures and can be mounted or taken down by inexperienced labor.

A Novel Breakwater for Algoma Harbor, Wis.

The existing harbor at Algoma, Wis., is in the mouth of Wolf (or Ahnapee) River, connected with Lake Michigan by a channel protected in the usual manner by wooden piers. With the increasing draft of vessels the old harbor has become useless, cannot be deepened economically by reason of the bed of the river being rock, and if deepened would be unduly effected by wave action.

A small outer harbor is to be secured by the construction of about 928 lin. ft. of pile or plank crib pier and about 500 lin. ft. of breakwater made of reinforced concrete caissons. About 650 ft. of old pier will be removed and the harbor will be dredged to a depth of 16 feet below datum. The cost of the work, including repairs to the north pier, will be about $144,000.



Caissons for Algoma Breakwater.

The principal feature of the work from the standpoint of engineering interest is the breakwater, which will consist of reinforced concrete caissons, resting on pile foundations, filled with meagre concrete and riprap stone, protected on both sides by riprap and capped with a superstructure of solid concrete, as shown on the accompanying diagrams. The foundation piles are to be supplied by the government; they will be driven to a minimum depth of 30 ft. below datum or until a suitable resistance is developed and then cut off below water so as to secure a horizontal bearing for the bottom of the caissons at a depth of 11 ft. 4 in. below datum. After the pile tops have been cut off, the space between the piles and up to within 9 in. of the pile tops will be filled with small stone, care being taken that no stone shall project above the piles so as to prevent a caisson from coming to full bearing upon all its foundation piles. Before sinking the caissons, the tops of the piles will be brought to within ¼ in. of the proper grade by recutting the piles or by the use of shims.

A cast iron bearing plate, with upper and lower surface suitably roughened to sink into the pile below and the plank above when under pressure, will then be placed on top of each pile. This bearing plate will at the same time tend to equalize the bearing upon the piles and to increase friction between the piles and the caissons above. The caissons will then be sunk and adjusted in their proper positions.

Each caisson will be 24 ft. long, 15 ft. wide and 12 ft. 4 in. high, rectangular in horizontal and vertical sections, with one transverse wall across its middle. The outside walls will be 12 in. thick, the transverse wall 10 in. thick, and the bottom 16 in. thick. The walls and bottom of each caisson will be suitably reinforced with steel bars as indicated on the drawings. It is proposed to build these caissons on shore at a site where they can be conveniently launched to be towed out to the site of the breakwater. The bottom of each caisson will be laid on a timber floor 4 in. thick through which 8-in. wire spikes have been driven to secure a firm bond between the concrete and the wood. Bolts will be embedded in the caisson concrete for convenience in handling them and short pieces of iron pipe will be embedded in the walls for the admission of water to facilitate sinking, but all bolts and pipes projecting beyond the exposed faces of the concrete will be cut off flush eventually.

The caissons are to be moulded in forms made with special care to secure smooth surfaces and, so far as possible, waterproof concrete. The concrete will be a 1:2:4 mixture of Portland cement, sand and broken stone.

A temporary timber decking will be used during the launching and towing of the caissons, and, when necessary, there will be a temporary waterproofing of their exterior surfaces by an inexpensive method.

The permanent filling for the caissons will be riprap stone surmounted by a 4-ft. layer of meagre concrete. Before the riprap filling is placed timber posts long enough to extend up to the level of the top of the riprap will be placed in each caisson as indicated on the drawing. The surface of the riprap filling will be covered with a layer of burlap on which will be deposited the concrete filling. Where the concrete filling is not covered by the superstructure a 3½-in. course below the level of the finished surface will consist of a special finishing concrete made with small stones. A circular man-hole 2 ft. in diameter with a reinforced concrete cover will be moulded in the concrete filling of each compartment of each caisson. The space between the ends of adjacent caissons will be filled with small stones to a height of 1 ft. below the top of the caissons.

The concrete superstructure will be built of 1:3:5 concrete laid in 25-ft. sections with joints between adjacent caissons. The upper surface of the superstructure will be 4 ft. above datum at the center. Alternate isolated sections of superstructure will be moulded first, each section having suitable anchor bolts in each end to secure a firm bond with the intermediate sections to be laid later. A single thickness of tarred paper will extend entirely through each joint in the superstructure, thus forming distinct vertical joints between adjacent sections.

The improvements at Algoma Harbor have been designed and will be executed under the direction of Major W. V. Judson, Corps of Engineers, U. S. A., in charge of river and harbor improvements on the western shore of Lake Michigan, with offices at Milwaukee, Wis. To protect the interest of the United States, Major Judson patented the floatable reinforced concrete caisson in 1901. Docks and breakwaters have recently been built abroad on this system, but its first use in this country will be at Algoma. It is perhaps needless to say that Major Judson has donated to the United States the right to use his patent.

The Quartz Lamp is the latest electrical lighting apparatus. It is a mercury-vapor lamp with a quartz tube in a glass globe, and resembles an arc lamp in general appearance. It is to be used as a single lamp at 220 volts, and has a rating of 3,000 hefner candles, consuming 0.25 watt per hefner candle-power. Its life is given at 1,000 hours, and an advantage claimed for it is that it is unnecessary to replace any electrodes.

Australian Timbers for Cross Ties.

By C. O. Burge, M. Inst. C. E.

The visit of Mr. Faulkner, of the Atchison, Topeka & Santa Fé Railway, to Australia, to investigate the suitability of the timbers of that country to supply anticipated deficiencies in this country of ties and other railroad requirements, is an ample proof of the reality of the scarcity of which we have recently heard. His report will be eagerly looked forward to in this connection, but meanwhile it may be of interest to state some of the possibilities of Australia in relation to this supply, by one who has had, during recent years, a good deal to do with the construction of railways there, and necessarily with the classes and availability of the native timbers used in such work.

The timbers of the east part of the continent comprising Queensland, New South Wales and Victoria, and of the Island of Tasmania, differ considerably from those of Western Australia, but as the home consumption of the latter is not nearly so great as of the former, the quantity available for export will most likely prove to be greater in the Western State.

The preservation of timber in the Eastern States has not in the past been anything like what it should have been, considering what a magnificent asset to the country it is, including perhaps some of the finest descriptions of this material known to the world for the rougher classes of work. Recently, however, more care has been taken and consequently it is probable that restrictions on export will be increased rather than diminished. The following extract from the latest report, dated November last, of the Forest Department of New South Wales represents the general condition of the resources of the Eastern States, the figures in the last paragraph, however, referring to the single State only: "Although not of remarkable extent, few countries in the world contained timber resources surpassing in variety and quality those originally existing in the State of New South Wales. Among the hardwoods, of which there are about twenty varieties of good commercial value in the State, ironbark stands pre-eminent for strength and durability, and has acquired a world-wide reputation, which is being rapidly approached by the special qualities of tallow-wood, blackbutt, the mahoganies (two), spotted gum, gray gum, blue gum, and many other indigenous hard woods, in their suitability for a variety of purposes. In soft or brush woods, which include many timbers of striking beauty and handsome grain, there are about twenty-five varieties of known commercial value, as well as numerous species as yet unclassified and untested, the best known in this class being red cedar, the beeches (three), pines (three), beans (two), rosewood, onionwood, silky oaks (two), tulipwood, cudgerie, and native teak.

"The extent of these resources is very difficult to estimate with any degree of accuracy. Originally they were much greater than at present, the demands of occupation, coupled with past policies of indiscriminate ring-barking and general neglect to conserve them, having considerably diminished their original extent. With regard to available timber supplies, the official estimate, published in 1902, is considered fairly correct. The following is an extract: 'Although not well distributed, the State's timber resources are large, particularly in the coastal or eastern portion. Owing to rapidity of growth and abundant habit of reproduction, there is little danger of a shortage of hardwood timber, if sufficient land be devoted to forestry purposes. Of ordinary hardwoods, there is an extensive supply available and a large margin for export; in localities not immediately accessible, the forests of this timber are practically virgin. Ironbark, the most valuable hardwood, is comparatively scarce within easy reach; further back, there are yet fair supplies available. The timber resources of the highland zone, although not varied, are large, there being sufficient supply to meet present and future requirements. Inland, the supply in proportion to the area of territory is limited; in parts it is unequal to the demands of settlement; generally speaking, this portion of the State has been over-denuded by ring-barking, and timbers of commercial value are confined to the timber reservations.'

"At the present time it is roundly estimated that the extent of territory, Crown and private, containing timber of any commercial value, is from 15,000,000 to 20,000,000 acres; by latest figures, 7,749,579 acres of this is included in temporary reserves for the preservation of timber, and as this area has been examined in detail, it can be stated that it includes the best and most valuable portion of the State's forest resources. At the same time, outside the limits of this reservation, large areas of valuable forest containing timber of the best present and prospective commercial value are known to exist."

It should be explained that ring-barking means cutting a ring of bark round the trunk by which the tree is killed, the object being to confine the power of the soil to the production of pasture, which is paramount in Australia.

In this report, a complete forest survey is strongly advocated indicating species, quantity, maturity, and accessibility, but pending more exact information, we may give the acreage in nearest millions of the following Eastern States in regard to reservation:

	Total territory.	Forest area.	Forest area reserved.
New South Wales	199	20	7.75
Victoria	56	12	5.50
South Australia	578	4	0.20
Queensland	428	40	3.33
Tasmania	17	11	0.10
Total	1,278	87	16.88

Ironbark, which is the best by far of these timbers, is getting so scarce that it is not likely that much will be available for export except at a prohibitive cost, at all events, in the future. Already the railways of New South Wales, where it is most plentiful, formerly using this timber almost exclusively, have been obliged to resort to other kinds. Of the latter, however, there are some which are of excellent quality.

The life of the principal timbers of the Eastern States as ties may be generally taken as follows in their average climate: Ironbark, 25 years; gray gum, 22; tallow-wood and Murray red gum, 20; gray box, white stringy bark, white mahogany, 18; and blackbutt, 16. These timbers are all dense and so close grained that, if treatment were necessary, it could not be applied, impregnation being impossible, while they are felled at all times of the year and are not seasoned, but sent direct from the timber getters to the road or to whatever other purpose to which they may be applied. There is no doubt that as the more valuable kinds of timber get less available, the Australians will be convinced that they must cut during the winter only when the sap is down, and resort to a moderate amount, at all events, of seasoning.

The table in the next column gives the qualities of some hardwoods, according to careful experiments conducted by Professor Warren, M. Inst. C. E., at the University of Sydney.

It is necessary, in speaking of Australian timbers, to use the botanical names, as locally the same name is often given to totally different species.

It is hardly necessary to describe the ironbarks E. paniculata, E. crebra, E. sidirophloia, and E. sideroxylon, as they are not easily obtainable. Murray red gums, E. rostrata, are too far from seaboard, as is also E. obligua, which, moreover, the writer's experience is against, for ties, being too fissile. Tallow-wood, E. microcorys, is yellow in color, very durable, not liable to split or shrink and is much used in Australia for bridge decking as well as ties, and is exported for paving blocks. In spite of its name, it does not burn readily. It is fairly plentiful on the northern coast of New South Wales, along which a railway is just now being started. E. pilularis is pale colored and, though rather fissile, much used for ties and general purposes. It is fairly abundant on the coast. Blue gum, E. saligna, is red in color and easier to work than the timbers already mentioned, and is more used by the wheelwright and builder, while it is fairly in demand for street blocks and has succeeded well for ties. Gray gum is often mistaken for ironbark and is a good substitute for it for all kinds of heavy work, including ties, roof shingles and felloes. Spotted gum, E. maculata, bends easily and has been extensively used in wheelwright work, and largely exported for rolling stock under-framing. Hemiphloia is tough, hard and not fissile, and is used for nearly all heavy work, while it is very durable in contact with the ground.

Properties of Australian Hardwoods.

Name of timber.	Wt. per cubic foot.	Transverse strength modulus of rupture, 54 x 6 x 4 in.	Tensile strength.	Compressive strength, 12 x 3 x 3 in.	Shearing strength, 6 x 6 x 2 in.
		Lbs. per square inch, average.			
Iron bark	75.18	18,204	17,900	10,500	2,200
Tallow wood (*Eucalyptus microcorys*)	77.06	15,300	13,400	8,500	1,600
Black butt (*E. Pilularis*)	66.69	14,800	21,000	8,600	1,700
Blue gum flooded (*E. Saligna*)	73.64	14,700	15,900	7,800	1,800
Gray gum (*E. Punctata*)	67.32	17,600	22,000	9,500	2,100
Spotted gum (*E. Maculata*)	62.19	15,300	16,400	8,500	1,600
Gray or white box (*E. Hemiphloia*)	73.62	15,950	21,564	8,021	2,110
Murray red gum (*E. Rostrata*)	62.19	11,267	13,618	9,397	2,039
Stringy bark (*E. Obligua*)	71.33	13,063	15,976	6,098	2,089

Many of these timbers are so alike in grain and texture to each other, and to various worthless species, that engineers dealing with them are often deceived, a result only avoidable by the employment of local timber experts, which would have to be incurred by any purchaser from abroad.

As to cost of Eastern Australian hardwoods, an idea may be formed from the contract rates of the Public Works Department, New South Wales, according to latest returns, which were: Sawn iron-bark, 58 cents per cubic foot; sawn tallow-wood, 46 cents; sawn mixed wood, 40 cents. For hewn ties, which are of two sizes, 9 ft. by 10 x 5 in. for main lines and 8 ft. by 9 x 4½ in. for branch lines, both 4 ft. 8½-in. gauge, the government pays from 84 cents to 76 cents for iron-bark, and from 60 to 48 cents for other approved kinds, delivered on the railways near the forests. The inspection for export costs about 1 cent per tie. Delivered f.o.b. at Sydney it is probable that 25 to 50 per cent., according to distance of forest from port, would have to be added. The Indian Government has imported Australian ties to a great extent, and those large enough for their 5 ft. 6-in. gauge lines have cost them delivered at Calcutta $1.50 for iron-bark and from $1.20 to $1.40 for other kinds. Records show that 507,262 ties were shipped to India during the year ending June 30, 1907, and this is still going on, though one-fifth of the area of British India is under the control of its Forest Department with an annual out-turn of 3,020 millions of superficial feet.

As to the above rates, the construction of the North Coast Railway in New South Wales, already referred to, passing as it will do, through the best timber producing country, will no doubt lead to the lowering of rates. This State has been referred to chiefly as affording the best and largest available supply from Eastern Australia, but it may be regarded as typical of the neighboring States so far as its timber resources are concerned.

As to Western Australia, the chief timbers used for ties are Jarrah and Karri, which have been imported to the United Kingdom to a much larger extent than the hardwoods to which reference has been made. This has been chiefly for wood paving in London and provincial cities, but a considerable number of Karri ties have been in satisfactory use in England and also in India and Ceylon. The Jarrah (E. marginata) forests cover an area of about 8,000,000 acres, and the Karri (E. diversicolor) forests 1,200,000 acres, both not far from the coast, to which they are fairly well connected by railways. Professor Warren in his report on the experiments already referred to places these timbers under the headings given, as about equal to spotted gum, though in other respects very different, and it may be generally concluded that what has been said as regards the Eastern timbers largely applies to those of the West, and as they appear to be more advertised and better known, it is probable that the State is not so keen on restriction of export, having regard to its own needs.

In reviewing the whole matter, it may be fairly assumed that there is no question of quality in Australian supplies, if inspection is at all effective It is a matter of price. In this it must be remembered that doubling the life of a tie more than doubles its value on site, for one replacement is avoided. Treatment in this case is unnecessary, and for material of such strength as has been shown, economy in number of ties might be feasible.

Apart from these considerations is the question of bearing area, and it might be possible by adding ballast and, where new roads or renewals are in hand, increasing rail section, so to arrange that the number of the expensive imported ties should be reduced to a minimum. The number of ties to the mile in Australia, though furnished on the spot, is roughly, a mean between the European wide spacing and American narrow spacing practice in this respect, and the growing scarcity of suitable timber in the United States may lead to some modification of existing American custom as regards this matter. Mr. Faulkner will, no doubt, be able to furnish some information as to the cost of transit on which the whole question depends, but meantime the above considerations affecting the country of origin of the timbers now being investigated may not be unwelcome.

A 60,000-VOLT TRANSMISSION LINE will be built to supply energy to Nagoya, Japan, from a hydroelectric station on the Naiko River about 30 miles distant. The station will be fitted with four 2,500-kw. generating units. These will furnish three-phase 60-cycle current at 6,600 volts which will be stepped up to 60,000 volts by water-cooled transformers for transmission to the main substation just outside the city. Here the potential will be stepped down to 11,000 volts by water-cooled transformers and the energy will be transmitted underground to a distributing station through lead-armored cables, the city ordinance prohibiting an overhead transmission voltage exceeding 3,500. In the central distributing station the voltage will be stepped down to 3,400 volts by water-cooled transformers, at which potential it will be distributed throughout the city by both overhead and underground cables. The Naiko River is normally 40 ft. in depth, but in the rainy season the stream often rises 40 to 70 ft. above the low-water mark, which has made it necessary to prepare special designs for the dam.

The Cost of Hydraulic Dredging on the Mississippi River.

A Memorandum by Lieut.-Col. Clinton B. Sears for the Board of Engineers on the Improvement of the Ohio River.

The following data relate to the six best dredges in use by the Mississippi River Commission as to first cost, repairs and betterments, operating expenses, deterioration, and results obtained.

These dredges are the Delta, Epsilon, and Zeta, non-propelling, requiring services of a tender and pile sinker, and the Iota, Kappa, and Flad, self-propelling.

TABLE 1.—ORIGINAL COST OF PLANT.

Name.	Dredge.	Tender.	Pile sinker.	Total.
Delta	$124,940	$47,862	$2,884	$175,686
Epsilon	102,000	47,862	2,884	152,746
Zeta	109,000	47,862	2,884	159,746
Iota [a]	100,480	......	.....	100,480
Kappa [a]	134,600	......	.....	134,600
Flad [a]	134,600	......	.....	134,600

[a] Self-propelling. Average cost for non-propelling, $162,726; average cost for self-propelling, $123,227; average cost of one plant, $142,976 +.

To the first cost given in Table 1 should be added "alterations and betterments" as shown in Table 2, and distinguished from "repairs and renewals," as these alterations were due to experience gained and could be embodied in specifications for new plant without materially affecting the ultimate cost.

TABLE 2.—REPAIRS, RENEWALS, ALTERATIONS AND BETTERMENTS TO PLANT.

Name. Date of delivery.	Repairs and renewals.	Alterations and betterments.	Totals.
Delta, Aug., 1897......	$28,761.58	$20,634.20	$49,395.78
Epsilon, March, 1898...	21,381.17	1,094.35	22,475.52
Zeta, March, 1898......	20,318.06	1,128.17	21,446.23
Iota, Aug., 1900........	13,155.28	8,174.19	21,329.47
Kappa, July, 1901......	7,533.16	4,664.95	12,198.11
Flad, July, 1901.......	6,605.63	4.737.61	11,343.24
Tenders, Oct., 1899.....	....	....	[a] 10,718.93
Pile sinkers, Dec., 1898.	....	....	[a] 883.15

[a] Average of 4. Repairs and renewals, average of 6, $16,292.48; repairs and renewals (omit Delta), average of 5, $13,798.66; alterations and betterments, average of 6, $6,738.91; alterations and betterments (omit Delta), average of 5, $3,959.85.

As most of the extensive alterations occurred in the earlier years of the plant, the average of the last three years is regarded as a better guide for future estimates than the average for the last eight years. Repairs, renewals, etc., for last three years: Average of 6, $11,211.69; omit Delta, average of 5, $9,849.49.

TABLE 3.—COST OF FIELD OPERATIONS.

Name.	Number of seasons operated.	Total cost field operations.	Total hours in commission.	Total working hours.	Average cost per month in commission.	Cost of material used in field repairs.	Average cost per month. excluding field repairs.
Delta	7	$135,651.40	16,648	7,605	$5,866.71	$4,595.91	$5,667.95
Epsilon	7	120,444.42	14,891	5,159	5,823.65	4,310.65	5,615.23
Zeta	7	100,114.57	13,243	4,037	5,443.06	3,872.81	5,232.51
Iota	5	80,942.51	12,137	3,127	4,801.73	3,290.19	4,606.55
Kappa	4	58,780.57	9,411	2,882	4,497.08	1,881.42	4,353.14
Flad	4	62,218.32	9,561	3,200	4,685.41	997.79	4,610.27

Including field repairs, average monthly cost for operating a non-propelling dredge with tender and pile sinker, $5,711.14; same for a self-propelling dredge, $4,661.41; excluding cost of material for field repairs, the monthly cost of operating a non-propelling plant, $5,505.23; same for a self-propelling plant, $4,523.32.

In the office of the Mississippi River Commission for purpose of estimates, the monthly cost of operation in field, including field repairs, for non-propelling plant is taken at $5,500, and for self-propelling plant is taken at $4,500.

Assuming that needed repairs are made each year and the dredges kept in a condition of highest efficiency, the boilers, engines, and machinery should last twenty years and the hulls a like period, after which replating may be needed. The Mississippi River Commission estimates 5 per cent. for deterioration annually.

The rated capacity of these dredges, based on an assumed velocity of 13 ft. per second in the discharge pipe and a carrying capacity of 10 per cent. of sand, is 1,200 cu. yd. per hour for the Delta and 1,000 cu. yd. per hour for each of the other dredges, delivered through 1,000 ft. of pipe. In tests of the Delta, Epsilon, and Zeta, made in 1897, the results in Table 4 were obtained:

TABLE 4.—CAPACITY TEST OF THREE DREDGES.

	Average velocity per second.	Per cent. of sand.	Average sand per hour.
Delta	15.10 ft.	14.69	1,850 cu. yd.
Epsilon	16.78 ft.	20.68	2,553 cu. yd.
Zeta	16.48 ft.	11.14	1,364 cu. yd.

Field tests of these dredges, made under the conditions of actual dredging in 1898, gave the results in Table 5.

TABLE 5.—FIELD TESTS, 1898.

Dredge.	Duration of test, hours.	Average cu. yd. per hour.	Remarks.
Delta ..	27.38	1,295	Sand, max. rate 2,550 cu. yd. p. hr.
Epsilon	24.93	1,305	Sand.
Zeta ..	62.92	652	Blue clay and sand.

Tests were made in 1902, where only water was pumped. Figures in Table 6 were deduced on the assumption that had water and sand been pumped the output would have been essentially the same at the same velocities.

From tests made during actual dredging it is believed that 15 per cent. of sand is not an unreasonable percentage in free-flowing material.

TABLE 6.—CAPACITY OF TESTS.

Dredge.	Average velocity.	Cubic yds. per hour. 15% sand.	Cubic yds. per hour. 10% sand.	Length of pipe.
Delta	16.65	2,160	1,440	500 ft.
Epsilon	21.20	2,404	1,600	500 ft.
Iota	18.36	2,114	1,400	500 ft.
Kappa	21.35	2,342	1,560	240 ft.
Flad	16.75	1,944	1,296	480 ft.
Iota [a]	21.30	2,342	1,560	500 ft.

[a] With shrouded runner.

It is concluded that the pumps of any of these dredges are capable of handling from 2,000 to 2,500 cu. yds. of sand per hour and that the capacity of a dredge is limited only by the rapidity with which the dredged material can be loosened and fed to the pump.

In actual service these figures are not approached, though several of the dredges removed averages of 1,000 yd. per hour or over for several consecutive hours in favorable material. In December, 1904, working in exceptionally favorable material, the Epsilon removed an average of 1,972 yd. per hour for five consecutive hours, but how much was actually pumped and how much carried away by the current could not be determined.

Taking the averages of all the dredges for the past four years in all classes of material from tenacious clay, on which the jet has but little effect, to light sand, and considering only the time spent in actual dredging the followinng average actual capacities are obtained: 1901, 567.0 yd.; 1902, 481.6 yd.; 1903, 422.9 yd.; 1904, 537.1 yd.; average 500.0 yd. These figures are based on the method of operating on the Mississippi River, the dredges being at work about one-third of the total time and tied up at the bank about two-thirds of the time.

The average rate of 500 cu. yd. per hour can probably be counted on for twenty hours per day and twenty-five days per month, giving a total of 250,000 yd. a month.

If the time consumed in placing plant, changing cuts, cleaning boilers, field repairs, and other work connected with dredging, exclusive of towing, plus an allowance of 10 per cent. of the idle time for cleaning boilers and repairs, be taken as the working time the average output becomes 350 cu. yd. per hour, which may be regarded as the average hourly rate that can be maintained for long periods of time in material such as is found in Mississippi River bars. This rate maintained hourly for a full month would give 252,000 yd. per month.

The contract price of the Harrod, now under construction, complete with pipe line and all auxiliaries, is $238,998.17. Its rated capacity, based on an estimated velocity of 22 ft. per second in the discharge pipe and a carrying capacity of 10 per cent. of sand, will be 2,100 cu. yd. per hour.

The cost of operating the Harrod is estimated at $5,500 per month while in commission, assuming her to be operated under approximately the same conditions as the other Mississippi River Commission dredges.

In cutting channels through bars the dredges are so handled that the cuts are spaced 8 to 10 ft. apart, the intervening ridges being leveled by the action of the current. To make a channel 250 ft. wide requires an average of six cuts by the Delta (suction head 34 ft. wide), 9 by the Epsilon and Zeta (suction head 20 ft. wide), and eight by the Iota, Kappa, and Flad (suction head 24 ft. wide).

The depth of cut varies in different cases from 2 to 10 ft., 4 ft. being a fair average.

For a 4-ft. cut the excavation of a channel 1,000 ft. in length involves the removal of 34,000 cu. yd. by the dredge. Based on an average capacity of 250,000 yd. per month this would give about 7,350 ft. of channel as the monthly capacity of one dredge. This takes no account of time consumed in towing from bar to bar. If such towing be required or if the average depth of cut is much over 4 ft. the figure must be reduced accordingly.

In actual service in the past four years the average performance of the six dredges above mentioned, counting all working time, including towing, has been at the rate of about 7,500 ft. of channel per month, the average depth of cut being 4 ft. Owing to the necessary stoppages for cleaning boilers and making repairs, however, this rate cannot be kept up for an entire month. A reduction of about 12 per cent. should be made for these contingencies, giving 6,600 ft. as the average length of bar formation per month through which one of these dredges can open channels 250 ft. wide, 9 ft. deep, under the conditions of Mississippi River dredging.

The season for 1904 lasted four months, which would give 26,400 ft. of bar, or about 5 miles, as the season's limit for one dredge.

From a study of the first three tables above it will be seen that the first cost, repairs and renewals, and operating in the field is less for a self-propelling plant than for a non-self-propelling plant.

The degree of efficiency with which dredges can be operated will depend a great deal upon the judgment of the engineer in local charge in selecting sites for the cuts and his skill in working the dredges to the best advantage.

Should a study of the bars as to their material show a preponderance of gravel or gravel mixed with clay or tough silt it may be necessary to change the design of the cutters for the dredges and this may result in greater first cost and less speed in cutting channels.

Book Notes.

Few books on engineering subjects have attained the immediate popularity of Prof. C. C. Thomas' "Steam Turbines," the first edition of which was reviewed at considerable length in this journal on March 17, 1906. The third edition has just appeared. Its new features, as pointed out by the author, are new problems in the design of the Curtis and the Parsons types of turbine, suggestions regarding turbine analysis, and a diagram of the heat-content of steam, the superheated region of which is plotted from the results of the author's recent investigation of superheated steam, communicated to the recent convention of the American Society of Mechanical Engineers. This diagram is laid out as suggested by Dr. Mollier, the co-ordinates in it being entropy and total heat-content. This diagram is considered particularly convenient because the heat-units are read on straight lines instead of on curves, as in the temperature-entropy diagram. The new edition of the book also contains information relating to recent applications of steam turbines to marine propulsion. For the benefit of those to whom the book is unfamiliar and who have not access to the review of the first edition, it may be stated that it is what may be called a practical book of the best class. That is to say, the scientific and experimental facts upon which the turbine design is based are stated fully and methods of calculation in actual commercial use among the best designers are employed in working out the problems stated. This enables the reader to understand the use of various diagrams and graphical methods of analysis which are of much value in real designing work. The book is marked by the large amount of experimental results that are given to check theory and guide the engineer. The volume well deserves the position it has won as a standard work on this important subject. (New York: John Wiley & Sons, $4.00.)

At the present time no feature of railway work is attracting more attention than signaling. The number and variety of signal appliances now used on our railways is an indication of the need of simplification existing in this branch of railway affairs. Simplification is impracticable, however, without a thorough understanding of the present state of the art, and nowhere is this stated so clearly as in Mr. Ralph Scott's "Automatic Block Signals and Signal Circuits." This book gives in fairly small compass a comprehensive review of the appliances now actually in use. It does not attempt to review the history of the art, which is fortunate, for the number of appliances that have been tried and discarded is legion and an enumeration of them is hardly necessary at the present time. The book opens with a statement of the essential features of signaling, so described that a reader of average intelligence can understand without much trouble what is being discussed. Simple circuits are then taken up, after which normal-danger circuits, normal-clear circuits and semi-automatic circuits are described. Following this the various types of batteries used in signal work are explained and the track circuit is described. Controlled manual systems of signaling are then taken up, and afterwards motors, relays and other apparatus are explained. The systems of different signal companies are next described and all-electric interlocking, three-position and electro-gas and other recent systems are explained in considerable detail. Electric railway signals receive special attention, and this portion of the book will doubtless make it particularly valuable to the many interurban electric railway companies which have of late come to understand the necessity of protecting their lines by complete signal systems. The volume closes with a chapter on maintenance. The book is the only up-to-date work on the subject, and as it is written by a specialist in signaling who has received the assistance not only of manufacturers of signal apparatus but also of the signal engineers of many leading railroads, it is an authoritative as well as comprehensive treatise on the subject. (McGraw Publishing Co., New York, $2.50.)

Some months ago there was printed in this journal a review of some important experiments in the hydraulic laboratory of the University of Wisconsin to ascertain the working characteristics of centrifugal pumps. The theory of such pumps has now advanced to such a stage that it is highly desirable for the details of theory to be checked by most careful tests. This work requires unusual facilities, and as the University of Wisconsin is one of the fortunate possessors of a laboratory where research of this nature can be conducted, it is gratifying to learn that the investigation of a 6-in. vertical centrifugal pump has been carried out there in the elaborate manner necessary to furnish the experimental information so badly needed. A very complete description of the work has been written by Mr. C. B. Stewart and published under the title "Investigation of Centrifugal Pumps." The results are given in tables and diagrams and are accompanied by a discussion of the theory of such pumps and of the tests themselves. The book also contains a descriptive index of engineering literature on centrifugal pumps from 1840 to 1907. (Madison: University of Wisconsin, 50 cents.)

Under the title "Retrieval at Panama," Mr. Lindon W. Bates has reprinted some articles contributed to the "New York Press" which attracted much attention at the time of their publication. These articles have been elaborated into a book of 454 pages, profusely illustrated, in which not only the design of the canal in its broad aspects, but also its general details, its commercial aspects, and its construction are discussed at great length. For many years the author has been making a sort of hobby of the Panama Canal, and has collected a library of official reports, books, pamphlets, maps and a mass of information obtained by correspondence and many visits to the Isthmus, which is of surprising extent. His criticisms of the work are many and stated in a most forceful manner. Naturally enough, he advocates the type of canal which he outlined some time ago, which has been described at considerable length in previous issues of this journal. The book is of a controversial nature, but is one of those works which contain a great deal of interesting information and criticism. (The Technical Literature Co., New York, $5.00.)

Letters to the Editor.

New Method of Wharf Building.

Sir:—A decidedly new departure in wharf-building has recently been taken on the San Francisco water front. It lies in putting into practical use reinforced concrete pier casings according to a new system designed by Mr. F. A. Koetitz. Reinforced concrete wharf piers have been in use for quite a number of years on the San Francisco water front, but these have had wooden casings composed of stave pipe, hooped with steel. The use of reinforced concrete in both cases is designed for the protection of encased wooden piles from the ravages of marine insects.

The use of wood stave pipe presupposes the ultimate decay of the wood, and the permanent integrity of the enclosed concrete, for which the wood is used as a form. The use of concrete casing presupposes the permanent integrity of the entire original substance of the pier.

The new wharf in question was built near Filbert Street on the Sea Wall. It is 30 x 180 ft. in surface area and has 31 supports, which consist of the concrete-cased piers mentioned. The reinforced concrete casings were manufactured at a factory situated at some distance from the proposed wharf. In their shaping, cylindrical wooden forms with wooden cores were employed. The forms were made of stave pipe of Oregon pine, and were laid horizontally for filling. Along the top of the forms were left openings through which the wet concrete was poured. The concrete casings were formed with a 20-in. inside diameter, and a 24-in. outside diameter and were made 22 ft. long, thus forming a shell 2 in. in thickness, and of the length designated.

In detail the casings were constructed of steel reinforcing rods and coils and rich concrete; the concrete being made of one part Portland cement and three parts aggregates. The mixture was made sufficiently wet to pour easily through the openings in the forms, and then the forms were well shaken so as to secure a good settlement of the concrete within, as well as to force out any air bubbles that might form.

The forms were taken from the upper parts of the casings generally in two days, but were left on the lower portions about a week. Then the forms were taken away completely and the casings removed under cover in the factory, where they were allowed to remain four weeks for additional hardening. Mr. Koetitz says that casings of this kind should be left to harden in open air from one to two months before using, according to the quality of the cement used in making the concrete.

As soon as the casings were ready for use they were loaded upon scows and transported to the site of the wharf. The wharf piers were driven in 15 ft. of water and into a bed of riprap rock, composing the sea wall. In the first place a wooden pile of Oregon pine, 16 in. in diameter, was driven to a firm foundation. Over this pile was fitted a wooden pilot, armed with a heavy steel shoe, and then this pilot was driven into the riprap rock at the bottom in order to make an opening sufficiently large to receive the reinforced concrete casing. Then over and embracing this wooden pile one of these concrete casings was lowered and driven to place. In order to facilitate the driving of the casings, they were formed with a shoe on the lower end. This shoe acted as a guide in driving, as well as excluding the entrance of any excess of sand or mud through the bottom, reducing the amount of excavation to a minimum.

The casings were driven to place with a common pile driver to a depth of 7 ft. into the bed of riprap rock. In fact they were sunk usually until their upper ends were some 2 ft. too low to receive the superstructure of the wharf, and the adjustment in height was made by clamping wooden forms around the top of the casings and filling them with concrete to the proper level.

It has been said that the casings were driven with a common pile driver. This is true; but in the driving, what is known as a "cushion cap" was used. This cap consisted of a ring of sole leather, three layers in thickness, placed on the top of the casing. On top of the leather ring was placed a hardwood cap about 6 in. in thickness, to the top of this was bolted a short iron cylinder filled with sawdust. On top of this still was placed another wooden cap with a piston fitting into the cylinder and resting upon the sawdust. Upon this upper cap the main driving cap, consisting of a 3-in. iron plate and a 5-in. steel standard was made to act. The pile hammer acting upon all exerted a central blow upon the concrete casing.

After being driven to place, the casings were pumped clear of water, sand and mud, and the space intervening between the wooden pile, or core, and the casing filled with common concrete, thus completing the solid formation of the wharf pier. H. A. Crafts.

Town Resurveys.

Sir: Referring to your editorial on "Resurveys of Small Towns" in the issue of Feb. 29, the writer, while not seeking self-advertisement, wishes to call your attention to the fact that in his book, "Engineering Work in Towns and Small Cities," this subject of the resurveying of small towns and the resurvey of lots is treated with a fulness not to be found in any other book. The literature for the men who are called to administer the affairs of small places has not been extensive and this book (which has had a most flattering sale) was written expressly for them.

In the experience of the writer he believes more trouble in small places has resulted from cheap and faulty resurveys than from original surveys, in this agreeing entirely with your editorial. The following extract from page 159 of the book mentioned shows the position taken on the subject of resurveys:

"If these surveyors had been commissioned to survey the whole town and their records kept carefully the troubles would not be so great. But the surveys were isolated ones made at a cost satisfactory to the lot owner and the price seldom large enough to enable a man to do all the work that was really necessary to do a correct job, etc."

Again, in regard to records (page 268):

"The too common fault with the conduct of the office of town or city engineer in the small place is that records are poorly kept, or that there are no records worthy of the name. Rather it is a misfortune. * * * As the office is unfortunately a spoils place to be fought and scrambled for yearly, by men who should possess professional brotherly love; as the pay is poor, the bills are paid grudgingly and often cut down, there is little heart left in a man to lead him to keep good records for the benefit of his successor, who may have maligned him to secure the position. Nevertheless he is a public officer and should keep complete records of all work done in his official capacity during his incumbency. If he walks out of office and retains notes the lack of which will embarrass his successor, he is practically a thief. It was once common for the retiring town or village engineer to retain his notes when he went out, in order to sell copies to his successor."

The writer knows of places where the engineer who did keep good, accurate records lost his position because of that fact. The argument was made that no harm could result from the change, as his records were so complete that another man could take up the work readily and the town lose nothing. So much for the reward of the conscientious man. The writer also knows of a number of cities, some of quite a size, where the incumbent is manifestly unfit and when special work is to be done the city always employs outside engineers. Yet the unfit man holds his place through all political changes simply because he has no records worthy of the name, and the people are afraid that a new man in the office will cause innumerable lawsuits. They firmly believe their engineer (while they admit his general engineering unfitness) knows so much about corners that a surveying instrument is more of an incumbrance than an aid. "He has it all in his head," they say.

Yours truly,

Ernest McCullough.

Chicago, March 1.

Flattening Rolled Tracings.

Sir: One of the greatest of the petty worries of an engineer is a rolled-up map, especially if it is a tracing, and it is due to this reason, to a great extent, that the system of flat filing is becoming so popular. The writer was lately engaged in installing a flat map filing system in a railroad office to take the place of a system in which the maps were all in rolls. Many of the maps in this office had been rolled up and stored away, as it were, for nearly twenty years.

The question as to how to flatten these maps, that they might lie easily in drawers, naturally presented itself with great force, and was often discussed. Prints gave no trouble, as they were simply immersed in water, and then hung up to dry again. This treatment, of course, was out of the question in regard to tracings.

The writer at last hit upon the following scheme: A small oil heater was secured and lit. The tracings to be flattened were then rolled up in the reverse order of what they had been, and were then held, more or less funnel-shaped over the heater, thus allowing the heat to circulate all over the surface of the map. It was found that upon unrolling, the tracings would lie flat, and gave no more trouble.

The writer has no doubt that there are other methods for flattening a refractory rolled-up tracing, but has never been able to learn of any simple one. If there are any other good methods, he is sure that engineers would be grateful to hear about them. Jos. F. Storz, C. E.

Wilkes-Barre, March 7.

Draft-Regulating Device.

Sir: There is a device for changing drafts of a furnace, in successful operation in the residence of Wm. H. Stanley, of this city, which is even more simple than the contrivance described by Mr. P. W. Kafer, of Lawrenceville, N. J., in the issue of Feb. 29. The prime mover of this arrangement is the spring of the alarm of an ordinary alarm clock; the first revolution of the key of the alarm releases a lever, which in turn releases a weight which reverses the check and fire-door drafts. As suggested by Mr. Stanley, a similar contrivance could be arranged to turn on the gas and light it to cook the morning bowl of oatmeal. This device is the result of the inventive genius of Mr. Stanley's son, at present a student of the University of Wisconsin.

Very truly yours,

Carl C. Witt.

Sioux Falls, S. D., March 5.

Concrete Beam Reinforcement.

Sir: Mr. Jacob's treatment of the concrete beam in your issue of March 7 is certainly novel. Of all theories of reinforcement calculated to take non-existent stresses, his is the first to place tension reinforcement in the neutral surface. Mr. Jacob deserves all credit for this conception. The result of his arrangement is to throw the neutral axis upward in the center, giving a curved neutral surface that defies all mathematical treatment. Despite his assurance that if bars be placed to fill one-fourth of the lower shaded triangle the concrete can easily be poured I wish to say that I doubt that the performance is possible.

Accepting his own formulae, however, deduced for a beam whose width is one-half the depth to the lowest line of reinforcement, we have: $d = \sqrt[3]{(0.0135M)} = 0.24\sqrt[3]{M}$. If the commonly accepted formulae be used for the same example we get $d = 0.26\sqrt[3]{M}$, or practically the same gross dimensions for the beam.

The characteristic features of the new method is, however, only revealed when the amount of steel is compared for the two cases. Mr. Jacob calls for one-fourth the area of his lower triangle which is the same as $1/72\ d^2 = 0.014d^2$.

The common fromulae use only $1/160\ d^2 = .00625\ d^2$. In other words the proposed method calls for $.014/.00625 = 2.25$ times as much steel as those in use. The idea of getting the steel up as high as the neutral axis evidently don't promote economy of materials or labor.

Bruno C. Lechler.

Ithaca, March 11.

A Burst Copper Steam Pipe, used for superheated steam at about 170 lb. pressure and 200° to 210° C., has been investigated by Prof. C. Bach. The pipe burst under a pressure of about 166 lb., the fracture mostly following one edge of the overlapping brazed joint. The conclusion drawn by Professor Bach from his investigation is that copper pipes should not be used for superheated steam temperatures above 250° C. The metal in the neighborhood of the brazed joint was found to have been overheated, resulting in a coarse granular structure and in cracking at places. The position of the burst and of certain cracks, commencing on the inside where the overlap joint terminated, indicates that there had been considerable stress due to bending at that point. The joints had been finished thicker than the rest of the pipe, its mean line not being circular, and Professor Bach estimates that the additional stress thus caused was important.